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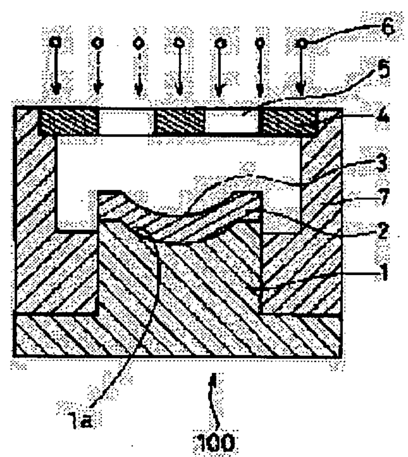
(54) PRODUCTION OF OPTICAL ELEMENT AND PRODUCTION OF ROTATION ASYMMETRIC MOLD FOR MOLDING OPTICAL ELEMENT

(57)Abstract:
PURPOSE: To easily obtain an optical element having an optical function surface of non-rotation symmetric shape by pressing an optical element raw material with a mold having an optical function surface of non-rotation symmetric shape formed by unevenly etching the rotation-symmetric surface of the mold base material.
CONSTITUTION: In a method for producing an optical element having a rotation non- asymmetric non-spherical surface on the optical function surface by heating and pressing a pair of molds wherein either one of the molds has a rotation non-asymmetric surface and an optical raw material disposed between the molds, an intermediate assembly 100 having a mask 4 disposed above the surface 1a of a mold base material 1 or the surface 3 of a protecting film disposed thereon through a mask jig 7 and the mold base material 1 having the surface 1a on which a rotation symmetric non- spherical surface is preliminarily formed is disposed in an etching device. Argon ion beams 6 are downward irradiated from places above the mask 4 in order to etch the surface 1a of the mold base material 1 or the surface 3 of the protecting film 2. The mold base material 1 is thus processed into a mold having a rotation non-asymmetric spherical surface and can transfer the surface shape of the mold to the surface of a pressed optical element.



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JAPANESE [JP,08-290925,A]

CLAIMS DETAILED DESCRIPTION TECHNICAL FIELD PRIOR ART EFFECT OF THE INVENTION TECHNICAL PROBLEM MEANS DESCRIPTION OF DRAWINGS DRAWINGS

[Translation done.]

CLAIMS

[Claim(s)]
[Claim 1] Arrange an optical material between the molds of a pair and said optical material and said mold are heated to predetermined temperature. It is the manufacture approach of the optical element which imprints the configuration of said type of optical functional side on the front face of said optical material by pressing said mold. Said type of at least one optical functional side is the manufacture approach of the optical element formed when it is rotation asymmetry and said rotation unsymmetrical configuration etches a field symmetrical with rotation of a mold base material into an ununiformity.
[Claim 2] It is the manufacture approach of the optical element according to claim 1 which said type of rotation unsymmetrical configuration is formed by the dry etching method, and said dry etching method is in the condition which has arranged the mask in the location separated from the location adjacent to the symmetry-of-revolution front face of said mold base material, or the front face for rotation to the upper part, and is performed by irradiating an ion beam or a radical beam on the symmetry-of-revolution front face of said mold base material.
[Claim 3] It is the manufacture approach of the optical element according to claim 1 performed by forming said type of rotation unsymmetrical configuration by the wet etching method, and said wet etching method's forming the resist film in the symmetry-of-revolution front face of said mold base material at least except for the part of the predetermined configuration which should be etched, and dipping the symmetry-of-revolution front face of said mold base material in an etching solution at least.
[Claim 4] The manufacture approach of an optical element given in either of claims 1-3 said type of whose rotation unsymmetrical configurations are a toric side or a cylindrical side.
[Claim 5] Said rotation unsymmetrical configuration is the manufacture approach of an optical element given in either of claims 1-4 which are the configurations which produce the astigmatism component of shaft top wave aberration when an optical element imprints.
[Claim 6] The manufacture approach of an optical element given in either of claims 1-5 which formed the protective coat in said type of rotation unsymmetrical front face at homogeneity.
[Claim 7] Arrange an optical material between the molds of a pair and said optical material and said mold are heated to predetermined temperature. It is the manufacture approach of the optical element which imprints the configuration of said type of optical functional side on the front face of said optical material by pressing said mold. It is the manufacture approach of the optical element formed when said type of at least one optical functional side is rotation asymmetry and said rotation unsymmetrical configuration etches into an ununiformity a field symmetrical with rotation of the protective coat formed on the mold base material.
[Claim 8] It is the manufacture approach of the optical element according to claim 7 which said type of rotation unsymmetrical configuration is formed by the dry etching method, and said dry etching method is in the condition which has arranged the mask in the location separated from the location adjacent to the symmetry-of-revolution front face of the protective coat on said mold base material, or the front face for rotation to the upper part, and is performed by irradiating an ion beam or a radical beam on the symmetry-of-revolution front face of said protective coat.
[Claim 9] It is the manufacture approach of the optical element according to claim 7 performed by forming said type of rotation unsymmetrical configuration by the wet etching method, and said wet etching method's forming the resist film in the symmetry-of-revolution front face of the protective coat formed in the front face of said mold base material at least except for the part of the predetermined configuration which should be etched, and dipping the symmetry-of-revolution front face of said mold base material in an etching solution at least.
[Claim 10] The manufacture approach of an optical element given in either of claims 7-9 said type of whose rotation unsymmetrical configurations are a toric side or a cylindrical side.
[Claim 11] Said rotation unsymmetrical configuration is the manufacture approach of an optical element given in either of claims 7-10 which are the configurations which produce the astigmatism component of shaft top wave aberration when an optical element imprints.
[Claim 12] Arrange an optical material between the molds of a pair and said optical material and said mold are heated to predetermined temperature. It is the manufacture approach of the optical element which imprints the configuration of said type of optical functional side on the front face of said optical material by pressing said mold. It is the manufacture approach of the optical element formed when said type of at least one optical functional side is rotation asymmetry and said rotation unsymmetrical configuration forms the film to an ununiformity on the symmetry-of-revolution front face of a mold base material.

[Claim 13] said type of rotation unsymmetrical configuration — the sputtering method and PVD (physical vapor deposition) — law and CVD (chemical vapor deposition) — the manufacture approach of the optical element according to claim 12 which it shifts, and it is formed by that approach, and performs by being in the condition which has arranged in the location separated from the location where said approach touches the symmetry-of-revolution side of said mold base material in a mask or the symmetry-of-revolution side chosen from law to the upper part, and irradiating a particle in the symmetry-of-revolution side of said mold base material.
[Claim 14] The manufacture approach of an optical element according to claim 12 or 13 that said type of rotation unsymmetrical configuration is a toric side or a cylindrical side.
[Claim 15] Said rotation unsymmetrical configuration is the manufacture approach of an optical element given in either of claims 12-14 which are the configurations which produce the astigmatism component of shaft top wave aberration when an optical element imprints.
[Claim 16] The manufacture approach of the rotation asymmetrical type for optical element shaping which etches the symmetry-of-revolution front face of said mold base material into an ununiformity by arranging in the location which separated the mask from the location adjacent to the symmetry-of-revolution front face of a mold base material, or the front face for rotation to the upper part, and irradiating an ion beam or a radical beam on the symmetry-of-revolution front face of said mold base material.
[Claim 17] The manufacture approach of the rotation asymmetrical type for optical element shaping which etches the symmetry-of-revolution front face of said mold base material into an ununiformity by forming the resist film in the symmetry-of-revolution front face of a mold base material at least, and dipping the symmetry-of-revolution front face of said mold base material in an etching solution at least except for the part of the predetermined configuration which should be etched.
[Claim 18] The manufacture approach of the rotation asymmetrical type for optical element shaping which etches the symmetry-of-revolution front face of said protective coat into an ununiformity by arranging in the location which separated the mask from the location adjacent to the symmetry-of-revolution front face of the protective coat formed on the mold base material, or the front face for rotation to the upper part, and irradiating an ion beam or a radical beam on the symmetry-of-revolution front face of said protective coat.
[Claim 19] The manufacture approach of the rotation asymmetrical type for optical element shaping which etches the symmetry-of-revolution front face of said protective coat into an ununiformity by forming the resist film in the symmetry-of-revolution front face of the protective coat formed on the mold base material at least except for the part of the predetermined configuration which should be etched, and dipping the symmetry-of-revolution front face of said protective coat in an etching solution at least.
[Claim 20] The manufacture approach of the rotation asymmetrical type for optical element shaping given in either of claims 16-19 said type of whose rotation unsymmetrical configurations are a toric side or a cylindrical side.
[Claim 21] Said rotation unsymmetrical configuration is the manufacture approach of the rotation asymmetrical type for optical element shaping given in either of claim 16 and others [20] which are the configuration which produces the astigmatism component of shaft top wave aberration when an optical element imprints.
[Claim 22] The manufacture approach of the rotation asymmetrical type for optical element shaping which forms the film to an ununiformity on the symmetry-of-revolution front face of a mold base material.
[Claim 23] said type of rotation unsymmetrical configuration — the sputtering method and PVD (physical vapor deposition) — law and CVD (chemical vapor deposition) — the manufacture approach of the rotation asymmetrical type according to claim 22 for optical element shaping which it shifts, and it is formed by that approach, and performs by being in the condition which has arranged in the location which separated from the location where said approach touches the symmetry-of-revolution side of said mold base material in a mask or the symmetry-of-revolution side which chooses from law to the upper part, and irradiating a particle in the symmetry-of-revolution side of said mold base material.
[Claim 24] The manufacture approach of the rotation asymmetrical type for optical element shaping according to claim 22 or 23 that said type of rotation unsymmetrical configuration is a toric side or a cylindrical side.
[Claim 25] Said rotation unsymmetrical configuration is the manufacture approach of the rotation asymmetrical type for optical element shaping given in either of claims 22-24 which are the configurations which produce the astigmatism component of shaft top wave aberration when an optical element imprints.
[Claim 26] The manufacture approach of the rotation asymmetrical type for optical element shaping according to claim 16 or 17 which formed the protective coat in said type of rotation unsymmetrical front face at homogeneity.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to the manufacture approach of the rotation asymmetrical type suitable for the manufacture approach of optical elements, such as an aspheric lens used for an optical instrument, and it.
[0002]
[Description of the Prior Art] Generally, the optical head for an optical disk or magneto-optic disks is always driven to radial [of a disk], in order to carry out the tracking of the recording surface top of a disk. Therefore, in almost all cases, the data on the recording surface of a disk are read, or although data are written in on a recording surface, the field outside a shaft of an objective lens is used. However, since astigmatism increases in the field outside a shaft, the optical-character ability of the lens in the field outside a shaft is inferior as compared with the optical-character ability in a paraxial field. Furthermore, the light from the semiconductor laser used as the light source has the astigmatic difference. Moreover, the 2nd lens for condensing to a photodetector the light reflected by the recording surface of a disk also has astigmatism. Therefore, the record reproducibility ability of an optical head will deteriorate further.
[0003] Therefore, various approaches are proposed in order to raise the engine performance of an optical head. as the 1st conventional example — JP,5-107467,A — at least — rotation — the objective lens which has an unsymmetrical optical functional side is proposed. The aberration on an optical axis can be made to generate an astigmatism component by forming the optical functional side of an objective lens in rotation asymmetry. The direction of an objective lens is adjusted so that aberration with the above-mentioned semiconductor laser or the 2nd lens may be made to offset by the astigmatism generated by the rotation unsymmetrical side. Moreover, the method of grinding an optical material directly and processing it as 2nd conventional example, is learned.
[0004] As 3rd conventional example, the manufacturing technology of the optical element by press forming is proposed by U.S. Pat. No. 5,015,280. The press-forming approach is a method of construction which imprints a mold configuration for an optical material. So, if a mold is processible with high precision, a desired optical element can be manufactured easily. When the optical element which should be manufactured is the symmetry of revolution like a symmetry-of-revolution aspheric lens, a mold can be formed using an ultraprecise CNC control machine tool. A mold rotates an optical axis as a core and feed motion of grinding or the cutting tool is carried out by the locus of the non-radii used as the cross-section configuration of a lens. Thereby, a mold can be manufactured comparatively easily in the configuration precision of about 0.1 micrometers.
[0005] The method of making for example, a JP,5-107467,A official report generate astigmatism by controlling a process condition, using the mold of a symmetry-of-revolution configuration as 4th conventional example is proposed.
[0006]
[Problem(s) to be Solved by the Invention] however, the conventional example of the above 1st — like — rotation -- it is very difficult as a practical question to manufacture an unsymmetrical optical element. in order [moreover,] to make an optical material and grinding stones, such as glass, rock mutually and to adjust each other and grind them by the direct grinding method which is the 2nd conventional example — inevitable — a flat surface — or only a spherical-surface configuration is processible. Therefore, by the conventional direct grinding method, it has the trouble that the optical element of a rotation unsymmetrical configuration cannot be manufactured.
[0007] the optical element which should be manufactured in the 3rd conventional example — rotation — when it has an unsymmetrical optical functional side, the processing machine which manufactures a mold is very complicated, and becomes an expensive highly precise and thing. That is, it must carry out during 1 rotation of a mold or a main shaft repeatedly, controlling advance retreat of a tool with high precision, attaching an encoder in the main shaft of a processing machine, and measuring angle of rotation of a mold, in order to detect angle of rotation of a mold, for example. Furthermore, it is difficult to secure the configuration precision of the mold formed of this processing. Moreover, in order to make the location of a tool follow rotation of a mold or a main shaft, a main shaft must be rotated very slowly, and it has the trouble that the floor to floor time of a mold will become long.
[0008] In the 4th conventional example, control management of molding temperature, a temperature gradient, compacting pressure, the shaping material configuration, etc. must be carried out with high precision. Furthermore, it has the trouble that it is difficult to secure the yield in the mass production of an optical element, and the direction of the astigmatism of a lens does not become settled.

[0009] As mentioned above, it was difficult to manufacture the optical element of a rotation unsymmetrical configuration by the conventional manufacture approach. The purpose of this invention is offering the manufacture approach of the mold suitable for the approach and it which manufacture easily the optical element which has the optical functional side of a nonrotation symmetry configuration.

[0010]

[Means for Solving the Problem] In order to attain the above-mentioned purpose, the manufacture approach of the optical element of this invention Arrange an optical material between the molds of a pair and said optical material and said mold are heated to predetermined temperature. It is the manufacture approach of the optical element which imprints the configuration of said type of optical functional side on the front face of said optical material by pressing said mold. Said type of at least one optical functional side is rotation asymmetry, and said rotation unsymmetrical configuration is formed by etching a field symmetrical with rotation of a mold base material into an ununiformity.

[0011] In the above-mentioned configuration, said type of rotation unsymmetrical configuration is formed by the dry etching method, it is in the condition which has arranged the mask in the location separated from the location adjacent to the symmetry-of-revolution front face of said mold base material, or the front face for rotation to the upper part, and, as for said dry etching method, it is desirable to carry out by irradiating an ion beam or a radical beam on the symmetry-of-revolution front face of said mold base material.

[0012] Or in the above-mentioned configuration, it is desirable to carry out by forming said type of rotation unsymmetrical configuration by the wet etching method, and said wet etching method's forming the resist film in the symmetry-of-revolution front face of said mold base material at least except for the part of the predetermined configuration which should be etched, and dipping the symmetry-of-revolution front face of said mold base material in an etching solution at least.

[0013] In each above-mentioned configuration, it is desirable that said type of rotation unsymmetrical configuration is a toric side or a cylindrical side. Moreover, in each above-mentioned configuration, when said rotation unsymmetrical configuration is imprinted by the optical element, it is desirable that it is the configuration which produces the astigmatism component of shaft top wave aberration. Moreover, in each above-mentioned configuration, it is desirable to form a protective coat in said type of rotation unsymmetrical front face at homogeneity.

[0014] On the other hand, the manufacture approach of another optical element of this invention arranges an optical material between the molds of a pair. It is the manufacture approach of the optical element which imprints the configuration of said type of optical functional side on the front face of said optical material by heating said optical material and said mold to predetermined temperature, and pressing said mold. Said type of at least one optical functional side is rotation asymmetry, and said rotation unsymmetrical configuration is formed by etching into an ununiformity a field symmetrical with rotation of the protective coat formed on the mold base material.

[0015] In the above-mentioned configuration, said type of rotation unsymmetrical configuration is formed by the dry etching method, it is in the condition which has arranged the mask in the location separated from the location adjacent to the symmetry-of-revolution front face of the protective coat on said mold base material, or the front face for rotation to the upper part, and, as for said dry etching method, it is desirable to carry out by irradiating an ion beam or a radical beam on the symmetry-of-revolution front face of said protective coat.

[0016] Or in the above-mentioned configuration, it is desirable to carry out by forming said type of rotation unsymmetrical configuration by the wet etching method, and said wet etching method's forming the resist film in the symmetry-of-revolution front face of the protective coat formed in the front face of said mold base material at least except for the part of the predetermined configuration which should be etched, and dipping the symmetry-of-revolution front face of said mold base material in an etching solution at least.

[0017] In each above-mentioned configuration, it is desirable that said type of rotation unsymmetrical configuration is a toric side or a cylindrical side. Moreover, in each above-mentioned configuration, when said rotation unsymmetrical configuration is imprinted by the optical element, it is desirable that it is the configuration which produces the astigmatism component of shaft top wave aberration.

[0018] Moreover, the manufacture approach of still more nearly another optical element of this invention Arrange an optical material between the molds of a pair and said optical material and said mold are heated to predetermined temperature. It is the manufacture approach of the optical element which imprints the configuration of said type of optical functional side on the front face of said optical material by pressing said mold. Said type of at least one optical functional side is rotation asymmetry, and said rotation unsymmetrical configuration is formed by forming the film to an ununiformity on the symmetry-of-revolution front face of a mold base material.

[0019] the above-mentioned configuration — setting -- said type of rotation unsymmetrical configuration -- the sputtering method and PVD (physical vapor deposition) — law and CVD (chemical vapor deposition) — it shifts and it is formed by that approach, and it is in the condition which has arranged in the location which separated from the location where said approach touches the symmetry-of-revolution side of said mold base material in a mask or the symmetry-of-revolution side chosen from law to the upper part, and it is desirable to carry out by irradiating a particle in the symmetry-of-revolution side of said mold base material

[0020] Moreover, in each above-mentioned configuration, it is desirable that said type of rotation unsymmetrical configuration is a toric side or a cylindrical side. Moreover, in each above-mentioned configuration, when said rotation unsymmetrical configuration is imprinted by the optical element, it is desirable that it is the configuration which produces the astigmatism component of shaft top wave aberration.

[0021] On the other hand, the manufacture approach of the rotation asymmetrical type for optical element shaping of this invention is arranged in the location which separated the mask from the location adjacent to the symmetry-of-revolution front face of a mold base material, or the front face for rotation to the upper part, and etches the symmetry-of-revolution front face of said mold base material into an ununiformity by irradiating an ion beam or a radical beam on the symmetry-of-revolution front face of said mold base material.
[0022] Moreover, except for the part of the predetermined configuration which should be etched, the manufacture approach of another rotation asymmetrical type for optical element shaping of this invention forms the resist film in the symmetry-of-revolution front face of a mold base material at least, and etches the symmetry-of-revolution front face of said mold base material into an ununiformity by dipping the symmetry-of-revolution front face of said mold base material in an etching solution at least.
[0023] The manufacture approach of still more nearly another rotation asymmetrical type for optical element shaping of this invention is arranged in the location which separated the mask from the location adjacent to the symmetry-of-revolution front face of the protective coat formed on the mold base material, or the front face for rotation to the upper part, and etches the symmetry-of-revolution front face of said protective coat into an ununiformity by irradiating an ion beam or a radical beam on the symmetry-of-revolution front face of said protective coat.
[0024] The manufacture approach of still more nearly another rotation asymmetrical type for optical element shaping of this invention forms the resist film in the symmetry-of-revolution front face of the protective coat formed on the mold base material at least except for the part of the predetermined configuration which should be etched, and etches the symmetry-of-revolution front face of said protective coat into an ununiformity by dipping the symmetry-of-revolution front face of said protective coat in an etching solution at least.
[0025] In each above-mentioned configuration, it is desirable that said type of rotation unsymmetrical configuration is a toric side or a cylindrical side. Moreover, in each above-mentioned configuration, when said rotation unsymmetrical configuration is imprinted by the optical element, it is desirable that it is the configuration which produces the astigmatism component of shaft top wave aberration.
[0026] The manufacture approach of still more nearly another rotation asymmetrical type for optical element shaping of this invention forms the film to an ununiformity on the symmetry-of-revolution front face of a mold base material. the above-mentioned configuration — setting — said type of rotation unsymmetrical configuration — the sputtering method and PVD (physical vapor deposition) -- law and CVD (chemical vapor deposition) — it shifts and it is formed by that approach, and it is in the condition which has arranged in the location which separated from the location where said approach touches the symmetry-of-revolution side of said mold base material in a mask or the symmetry-of-revolution side chosen from law to the upper part, and it is desirable to carry out by irradiating a particle in the symmetry-of-revolution side of said mold base material Moreover, in each above-mentioned configuration, it is desirable that said type of rotation unsymmetrical configuration is a toric side or a cylindrical side. Moreover, in each above-mentioned configuration, when said rotation unsymmetrical configuration is imprinted by the optical element, it is desirable that it is the configuration which produces the astigmatism component of shaft top wave aberration.
[0027] Furthermore, when etching a mold base material directly, it is desirable to form a protective coat in said type of rotation unsymmetrical front face at homogeneity.
[0028]
[Embodiment of the Invention]
(1st operation gestalt) The 1st operation gestalt of the manufacture approach of the mold suitable for the manufacture approach of the optical element of this invention and it is explained, referring to drawing 5 , drawing 12 , and drawing 13 from drawing 1 . The optical element 50 which should be manufactured by the approach of this invention is an aspheric lens, and is shown in drawing 12 . The optical functional side 51 of an optical element 50 is the rotation unsymmetrical aspheric surface, and has perpendicular **** 52 and level **** 53. It differs from vertical radius of curvature and horizontal radius of curvature. So, **** 52 and 53 connects a focus to two different points, respectively. An optical element 50 has astigmatism on the shaft. An optical element 50 is manufactured by carrying out press molding of the optical material arranged between the molds of a pair. At least, one of the molds has the rotation unsymmetrical aspheric surface, and the rotation unsymmetrical aspheric surface is imprinted by the front face of an optical material. So, the optical functional side 51 of an optical element 50 is formed.
[0029] Next, the manufacture approach of a mold of having the rotation unsymmetrical aspheric surface is explained. As shown in drawing 1 , the middle assembly object 100 possesses the mold base material 1, and a mask 4 and the mask fixture 7. A tungsten (W) and the carbon (C) of the mold base material 1 are made of the cemented carbide used as a principal component. In order to prevent the welding of a blemish and the optical material at the time of shaping on the front face of a mold, a protective coat 2 may be formed on surface 1a of the mold base material 1. The mask 4 is arranged in the location which only predetermined distance separated from the front face 3 of surface 1a of the mold base material 1, or a protective coat 2 up through the mask fixture 7. The argon (Ar) ion beam 6 is caudad irradiated from the upper part of a mask 4, in order to etch the front face 3 of surface 1a of the mold base material 1, or a protective coat 2. The mold base material 1 serves as a mold which has the rotation unsymmetrical aspheric surface, when a mold production process is completed.
[0030] The aspheric surface symmetrical with rotation is beforehand formed in surface 1a of the mold base material 1 by the approach for forming the conventional symmetry-of-revolution aspheric surface. The mold base material 1 rotates as a core the shaft corresponding to the optical axis of the optical element which should be manufactured.

And feed motion of the grinding stone is carried out so that the processing point that a grinding stone and a mold base material touch may draw the predetermined direction of an optical element 50, for example, the cross-section configuration of non-radii where **** 52 of drawing 12 was met. The configuration precision of the mold base material 1 processed by this processing method was about **0.1 micrometers. When forming a protective coat 2 in surface 1a of the mold base material 1, protective coats, such as a platinum-iridium (Pt-Ir) alloy, are formed by 3 micrometers in thickness by the spatter.

[0031] The slash section is a part covered with the mask 4 of the mold base material 1 so that clearly from drawing 2 . For example, the diameter of the shaping side of the mold base material 1 including the edge section is 5mm, and surface 1a or the diameter of 3 is 4mm. The magnitude of the rectangle opening 5 is 5mmx2mm, and each opening 5 sets spacing of 1mm, and is arranged in parallel.

[0032] Next, it arranges to the etching system which shows the above-mentioned middle assembly object 100 shown in drawing 1 to drawing 4 . With the 1st operation gestalt, the ECR (electron cyclotron resonance) ion beam etching system is used. An etching system possesses an etching chamber 9, the stage 10 where it is equipped with the middle assembly object 100, the ion beam accelerating electrode 11 prepared in the upper limit section of an etching chamber 9, and the ion gun 13 formed on the etching chamber 9.

[0033] If a stage 10 is equipped with the middle assembly object 100, air will be removed so that the interior of an etching chamber 9 may serve as a vacuum. Then, argon (Ar) gas is introduced in an ion gun 13 through the gas installation bulb 14, and the plasma 12 is generated. The ion accelerating electrode 11 pulls out Ar ion from the plasma 12, and irradiates an ion beam 6 at the middle assembly object 100. The atom or molecule of a front face 3 of surface 1a of the mold base material 1 or a protective coat 2 is flipped off by the collision of the ion which has come flying. Thereby, surface 1a of the mold base material 1 or etching processing of the front face 3 of a protective coat 2 is performed.

[0034] In the 1st operation gestalt, the diameter at the maximum equator of the middle assembly object 100 was 15mm. It equipped with seven middle assembly objects 100 on the stage 10 in an etching chamber 9. The diameter of the ion beam bundle from an ion gun 13 was 60mm. The mask 4 was separated from the front face 3 of surface 1a of the mold base material 1, or a protective coat 2 10mm. The etching conditions are as follows. They were acceleration voltage 800V of the pressure of 0.09Pa of introductory Ar gas, and an ion beam 6, current density 1.0 mA/cm2 of an ion beam 6, and irradiation time 3 minutes of an ion beam 6.

[0035] The time amount which processing per mold took was about 90 minutes (1 hour, a half) including the time amount which lengthens air, in order to make into a vacuum the interior of the assembly time amount of the middle assembly object 100, the time amount which sets the middle assembly object 100 in an etching chamber 9, and an etching chamber 9. If the diameter of an ion beam bundle can be enlarged further, many molds can be manufactured efficiently.

[0036] It measured to the X-axis and Y shaft orientations which show the cross-section configuration of the mold formed as mentioned above to drawing 2 and drawing 3 . A measurement result is shown in drawing 5 . the rotation after a configuration with an axis of ordinate symmetrical with the rotation before [in / in drawing 5 , an axis of abscissa expresses the distance from a mold core to point of measurement, and / point of measurement] etching, and etching -- the core of a mold is expressed for the amount of gaps with an unsymmetrical configuration as 0. Since the field in alignment with the Y-axis of the front face 3 of surface 1a of the mold base material 1 or a protective coat 2 is etched into homogeneity by ****** and the ion beam 6 with a mask 4 so that clearly from drawing 5 , the cross-section configuration of the mold of Y shaft orientations is not changing from a configuration symmetrical with the rotation before etching. On the other hand, since more fields which are distant from the core of a mold to X shaft orientations than a part for a core are exposed to an ion beam 6, the cross-section configuration of the mold of X shaft orientations inclines gently toward a periphery from the core. Consequently, the shape of surface 1a of the mold base material 1 after etching or surface type of the front face 3 of a protective coat 2 serves as rotation asymmetry like for example, a toric side. The overall radius of curvature of the mold of X shaft orientations becomes larger than the radius of curvature of the mold of Y shaft orientations.

[0037] Furthermore, another mold which has a front face symmetrical with rotation is beforehand prepared by the conventional approach. As shown in drawing 13 , the optical materials 60, such as glass and resin, are arranged among molds 61 and 62. Either of the molds 61 and 62 has the rotation unsymmetrical side formed by the above-mentioned etching approach, and another side has the symmetry-of-revolution side formed by the conventional approach. Molds 61 and 62 and the optical material 60 are heated by the predetermined temperature which the front face of the optical material 60 softens at least. Molds 61 and 62 are pressed by the predetermined pressure so that the shape of surface type of molds 61 and 62 may be imprinted by the front face of the optical material 60. then, molds 61 and 62 and the optical material 60 are cooled -- having -- rotation -- the optical element 50 which is the aspheric lens which has the unsymmetrical optical functional side 51 is obtained.

[0038] In the 1st operation gestalt, the amount of the maximum gaps of the cross-section configuration of the mold of X shaft orientations in the periphery section was set to 0.15 micrometers. The above-mentioned etching process was repeated 5 times, and 35 molds were manufactured in total. The configuration error of a mold was **0.02 micrometers to the amount of design gaps of 0.15 micrometers.

[0039] The press molding process was repeated and 1000 lenses were fabricated in the same mold. Optical-glass SF8 was used as an optical material. the optical element 50 cast using the above-mentioned mold -- for example, rotation of a toric side etc. -- since it has the unsymmetrical optical functional side 51, an optical element 50 generates astigmatism. When the optical-character ability of an optical element 50 was measured, each optical

element 50 generated the astigmatism of the almost same amount as the almost same direction. The average value of astigmatism was 30mlambda (mlambda: 1/1000 of the wavelength of the light source used), and was a value moderate as an objective lens of the optical head for optical disk units. Moreover, the wave aberration of the optical element 50 whole was also good. The optical head was assembled using this optical element 50. The optical element 50 is attached so that the radial astigmatism outside a shaft of an optical disk may be offset by the shaft top astigmatism by the rotation unsymmetrical aspheric surface. The reproducing characteristics of the optical disk by the optical head using the optical element 50 of the 1st operation gestalt were superior to the reproducing characteristics using the conventional optical head which used the lens of the conventional symmetry-of-revolution configuration.

[0040] A desired rotation unsymmetrical configuration can be formed in a mold by controlling distance, etching conditions, and the amount of etching with the front face 3 of the surface 1a or the protective coat 2 of the configuration of the opening 5 of a mask 4, a mask 4, and the mold base material 1. The optical element which generates the astigmatism for which it asks by that cause can be obtained.

[0041] With the 1st operation gestalt, in order to etch the protective coat of a mold base material or its front face, argon ion was irradiated, but the same configuration can be acquired even if it is the dry etching method using other ion and radicals. Furthermore, although the protective coat 2 was formed in surface 1a of the mold base material 1 before etching processing and the front face 3 of a protective coat 2 was etched when a protective coat 2 was formed, before forming a protective coat 2, surface 1a of the mold base material 1 may be etched into rotation asymmetry, and the after protective coat 2 may be formed in homogeneity. Furthermore, you may etch the front face 3 of surface 1a of the mold base material 1, or a protective coat 2 by making an ion beam operate it (scanning), without using a mask.

[0042] (2nd operation gestalt) The 2nd operation gestalt of the manufacture approach of the mold suitable for the manufacture approach of the optical element of this invention and it is explained, referring to drawing 8 from drawing 6 . In the 2nd operation gestalt, the configuration of the optical element which should be manufactured, and the process process of the optical element using a mold are substantially [as the case of the 1st operation gestalt] the same. However, the manufacture approaches of a mold of having the rotation unsymmetrical aspheric surface differ.

[0043] As shown in drawing 6 , openings 23 and 24 are removed, and the whole surface of the mold base material 20 is ************ by the resist film 22. Opening 23 is formed so that the front face 21 of the mold base material 20 may be countered. The opening 24 for forming a mark is formed so that edge section 21a of a front face 21 may be countered. The mold base material 20 which has the resist film 22 is dipped in the etching solution 25. So, the front face 21 of the mold base material 20 is etched into a rotation unsymmetrical configuration. The mold base material 20 is made of chromium alloy stainless steel tool steel.

[0044] The front face 21 of the mold base material 20 is roughly formed in the symmetry-of-revolution aspheric surface configuration by the conventional approach. The electroless-nickel-plating film (not shown) is given to the front face 21 of the mold base material 20 at least. Furthermore, the nickel-plating film on the front face 21 of the mold base material 20 is cut by the diamond tool using an ultraprecise engine lathe. So, the symmetry-of-revolution aspheric surface is made to the nickel-plating film on the front face 21 on the mold base material 20 so that it may be correctly in agreement with the cross-section configuration of the optical element 50 in alignment with **** 52 shown in drawing 12 . The 5 time diluent of a sulfuric acid was used as an etching solution 25.

[0045] For example, the radius of the front face 21 of the mold base material 20 was 2mm, and the width of face of flat edge section 21a was 1mm. Therefore, the total radius of the molding side of the mold base material 20 containing the edge section was 3mm. All the front faces of the mold base material 20 except openings 23 and 24 are ************ by the resist film 22 so that it may not be etched with the etching solution 25. Opening 23 is arranged in accordance with the shaft Y shown in drawing 7 . The width of face of opening 23 was 1mm, and die length was about 4mm. Opening 24 is formed on Shaft Y and the shaft X which intersects perpendicularly. The diameter of opening 24 was 0.6mm.

[0046] The etching solution 25 is filled by glassware with a diameter of about 200mm, and is kept warm by 40 degrees C. The ******** type base material 20 was arranged in the cage of 40-piece ****** by the resist film of 16mm of diameters at the maximum equator, and it dipped in the etching solution 25 for 5 minutes. Then, the cage was pulled up from the etching reagent 25, and pure water washed. Consequently, the nickel-plating film on the front face 21 of the mold base material 20 was etched into rotation asymmetry.

[0047] It measured to the X-axis and Y shaft orientations which show the cross-section configuration of the mold formed by the above-mentioned approach to drawing 7 . A measurement result is shown in drawing 8 . the rotation after a configuration with an axis of ordinate symmetrical with the rotation before etching [in / in drawing 8 , an axis of abscissa expresses the distance from a mold core to point of measurement, and / point of measurement], and etching — the core of a mold is expressed for the amount of gaps with an unsymmetrical configuration as 0. Since a part for the core of Y shaft orientations of the nickel-plating film on the front face 21 of the mold base material 20 is boiled with ************** and an etching reagent 25 by the resist film 22 and is etched more into homogeneity so that clearly from drawing 8 , the cross-section configuration of the mold of Y shaft orientations is not changing from a configuration symmetrical with the rotation before etching. On the other hand, since parts for many ************ and core of a mold are etched for the periphery of the nickel-plating film on the front face 21 of X shaft orientations by the etching reagent rather than a circumference part by the resist film 22, in the cross-section configuration of the mold of X shaft orientations, about 0.1 micrometers of circumference parts are high relatively to a part for a core. Furthermore, the depression is formed in the location which counters opening 24 in

the part of -3 from the distance (radius) -2 of drawing 8 . Consequently, the configuration on the front face of a mold serves as rotation asymmetry like for example, a toric side. The radius of curvature of the mold of X shaft orientations becomes small relatively rather than the radius of curvature of the mold of Y shaft orientations.
[0048] When the configuration of 40 molds formed by the above-mentioned approach was measured, the configuration error of the cross-section configuration of the mold of X shaft orientations was within the limits of -0.02 to +0.03 micrometers to the amount of average gaps of 0.1 micrometers, and dispersion was small.
[0049] In addition, in order to prevent the welding of a blemish and the optical material on the front face of a mold at the time of molding of an optical element, the protective coat with a thickness of 2 micrometers was formed in the rotation unsymmetrical side of a mold for the protective coat of a platinum-tantalum (Pt-Ta) alloy by the sputtering method.
[0050] Furthermore, other molds which have the symmetry-of-revolution aspheric surface are prepared. The optical material 60 made of polycarbonate resin is arranged among molds 61 and 62 like the 1st operation gestalt shown in drawing 13 . Either of the molds 61 and 62 has the rotation unsymmetrical side formed by the above-mentioned etching approach, and another side has the symmetry-of-revolution side formed by the conventional approach. After heating the optical material 60 and molds 61 and 62 to predetermined temperature, molds 61 and 62 were pressed by the predetermined pressure. Then, the optical material 60 and molds 61 and 62 were cooled. Thus, the optical element 50 was obtained.
[0051] By repeating such a press molding process, 1000 lenses were fabricated in the same mold. Since the optical element 50 manufactured by press molding using the above-mentioned mold has the rotation unsymmetrical optical functional sides 51, such as a toric side, as shown in drawing 13 , an optical element 50 generates astigmatism. When the optical-character ability of an optical element 50 was measured, each optical element 50 generated the astigmatism of the almost same amount as the almost same direction. The average value of astigmatism was 25mlambda (mlambda: 1/1000 of the wavelength of the light source used), and was a value moderate as an objective lens of the optical head for optical disk units. Moreover, the wave aberration of the optical element 50 whole was also good. The optical head was assembled using this optical element 50. As shown in drawing 7 and drawing 8 , the optical element was positioned by detecting the mark which shows the direction of rotation asymmetry. With the 2nd operation gestalt, since it is not necessary to actually measure astigmatism, in case an optical head is equipped with an optical element 50, an optical element 50 can be easily attached in the direction which has the optimal optical-character ability. The reproducing characteristics of the optical disk by the optical head using the optical element 50 of the 2nd operation gestalt were superior to the reproducing characteristics using the conventional optical head using the lens fabricated with the mold of the conventional symmetry-of-revolution configuration.
[0052] A desired rotation unsymmetrical configuration can be formed in a mold by controlling the configuration, the etching conditions, and the amount of etching of opening 23 of the resist film 22. The optical element which generates the astigmatism for which it asks by that cause can be obtained. Furthermore, an etching process is not limited to the example shown in drawing 6 . Some mold base materials 20 including a front face 21 may be dipped in an etching solution. In this case, what is necessary is just to form the resist film 22 in about 21 front face of the mold base material 20. The component of the etching solution 25 just etches the ingredient of the mold base material 20. With the 2nd operation gestalt, in order to etch the nickel-plating film on the front face 21 of the mold base material 20, the sulfuric acid was used, but other things may be used as long as it can etch the protective coat of a mold base material or its front face. Moreover, although the nickel-plating film on the front face 21 of the mold base material 20 was etched with the 2nd operation gestalt, the front face 21 of the mold base material 20 may be etched directly.
[0053] (3rd operation gestalt) The 3rd operation gestalt of the manufacture approach of the mold suitable for the manufacture approach of the optical element of this invention and it is explained, referring to drawing 11 from drawing 9 . In the 3rd operation gestalt, the production process of the optical element using the optical element and mold which should be manufactured is substantially [as the 1st operation gestalt] the same. However, the manufacture approach of a mold of having the rotation unsymmetrical aspheric surface differs from the 1st operation gestalt. the 3rd operation gestalt — setting — rotation — the sputtering method is used as the formation approach of an unsymmetrical mold.
[0054] As shown in drawing 9 , the middle assembly object 200 possesses the mold base material 30, and a mask 33 and the mask fixture 35. The mask 33 is arranged through the mask fixture 35 above the mold base material 30. From the upper part of a mask 33, sputtered particles 36 go caudad, come flying, and form the film 31 in the front face of the mold base material 30. The alumina of the mold base material 30 is made of the cermet used as a principal component.
[0055] In advance of a sputtering process, the symmetry-of-revolution aspheric surface is formed in surface 30a of the mold base material 30 by the conventional approach. The shaft corresponding to the optical axis of optical elements, such as a rotation unsymmetrical aspheric lens which should have the mold base material 30 fabricated, is rotated as a core. Feed motion of the grinding stone is carried out so that the processing point that a grinding stone and a mold base material touch may draw the non-radii cross-section configuration where the predetermined direction 52 of an optical element 50, for example, **** of drawing 12 , was met.
[0056] As shown in drawing 10 , the slash section is a part which has covered the mold base material 30 with the mask 33. For example, the diameter of surface 30a of the mold base material 30 was 6mm, and the magnitude of the rectangle opening 34 was 6mmx4mm. The distance of a mask 33 and surface 30a of the mold base material 30 was 5mm.

[0057] Next, 14 middle assembly objects 200 were arranged on the holder with a diameter [of a sputtering system] of about 100mm, the air inside a sputtering system was lengthened, and it was made the vacuum. Then, argon (Ar) gas was introduced in the sputtering system. The pressure of argon gas was set to 0.13Pa, and discharge was generated in RF power 100W. Sputtering was performed for 60 minutes by using Pt-Re as a target. Consequently, the film 31 which has uneven thickness was formed on surface 30a of the mold base material 30 so that it might become rotation asymmetry. With the 3rd operation gestalt, the ingredient of the film 31 is the platinum-rhenium (Pt-Re) alloy formed by the sputtering method. This film 31 functions also as a protective coat for preventing a blemish and the optical material welding at the time of shaping. The thickness of the film 31 in a part for the core of a mold was 2 micrometers. Moreover, the thickness of the film 31 in the location which is distant from the core of a mold 2.5mm to X shaft orientations was 1.87 micrometers. The amount of displacement of the cross-section configuration of the mold in X shaft orientations from a configuration symmetrical with the first rotation was 0.13 micrometers. the configuration error of a mold — an average — a variation rate — it was **0.02 micrometers to the amount of 0.13 micrometers.
[0058] The cross-section configuration of the mold of the X-axis and Y shaft orientations which are shown in drawing 10 was measured. A measurement result is shown in drawing 11 . In drawing 11 , an axis of abscissa expresses the distance from a mold core to point of measurement, and an axis of ordinate expresses the core of a mold for the amount of gaps of the configuration symmetrical with original rotation and the front face 32 of the film 31 which were formed on surface 30a of the mold base material 30 in point of measurement as 0. Since, as for a part for the core of surface 30a of the mold base material 30 in Y shaft orientations, ************** and the film 31 are formed on it with a mask 33 at homogeneity so that clearly from drawing 11 , the cross-section configuration of the mold of Y shaft orientations is not changing from the configuration of the beginning of surface 30a of the mold base material 30. On the other hand, since there are more amounts of the particle to which it adheres near the periphery section of the mold base material 30 in X shaft orientations near the core of surface 30a of ************ and the mold base material 30 with a mask 33 than the amount of the particle adhering to a periphery, the cross-section configuration of the mold in X shaft orientations turns into a configuration which inclines gently toward an outside from a core. Consequently, the shape of surface type of the mold corresponding to the front face 32 of the film 31 on the mold base material 30 serves as rotation asymmetry, such as for example, a toric side. The participation radius of curvature of X shaft orientations becomes larger than the radius of curvature of Y shaft orientations as a whole.
[0059] Furthermore, another mold which has the symmetry-of-revolution aspheric surface was prepared, and the optical material 60 made in optical-glass VC79 among molds 61 and 62 has been arranged like the 1st operation gestalt shown in drawing 13 . One side of molds 61 and 62 has the rotation unsymmetrical aspheric surface formed by the describing [above] sputtering method, and another side has the symmetry-of-revolution aspheric surface formed by the conventional approach. The optical material 60 and molds 61 and 62 were heated to predetermined temperature, and molds 61 and 62 were pressed by the predetermined pressure. Then, the optical material 60 and molds 61 and 62 were cooled. Thus, the optical element 50 was obtained.
[0060] Such a press molding process was repeated and 1000 optical elements were manufactured with the same mold. Since the optical element 50 cast with the above-mentioned mold has the rotation unsymmetrical optical functional sides 51, such as a toric side, an optical element 50 generates astigmatism. When the optical-character ability of an optical element 50 was measured, each optical element 50 generated the astigmatism of the almost same amount as the almost same direction. The average value of astigmatism was 25mlambda (mlambda: 1/1000 of the wavelength of the light source used), and was a value moderate as an objective lens of the optical head for optical disk units. Moreover, the wave aberration of the optical element 50 whole was also good. The optical head was assembled using this optical element 50. The optical element 50 is attached so that the radial astigmatism outside a shaft of a magneto-optic disk may be offset by the rotation unsymmetrical aspheric surface. The reproducing characteristics of the magneto-optic disk by the optical head using the optical element 50 of the 3rd operation gestalt were superior to the reproducing characteristics of the conventional optical head which used the lens of the conventional symmetry-of-revolution configuration.
[0061] A desired rotation unsymmetrical configuration can be formed in a mold by controlling the amount of the particle adhering to surface 30a of the configuration of the opening 34 of a mask 33, the distance of a mask 33 and surface 30a of the mold base material 30, sputtering conditions, and the mold base material 30 etc. The optical element which generates the astigmatism for which it asks by that cause can be obtained.
[0062] although the sputtering method was used as an approach of forming the film 31 with the 3rd operation gestalt — PVD (physical vapor deposition) — law and CVD (chemical vapor deposition) — law may be used. Moreover, although the film 31 which serves as a protective coat was formed in rotation asymmetry, an interlayer may be formed in rotation asymmetry and a protective coat may be formed on an interlayer at homogeneity.
[0063] In each above 1st, 2nd, and 3rd operation gestalten, as shown in each top view of drawing 2 , drawing 7 , and drawing 10 , although the whole mold of the mold base materials 1, 20, and 30 is a symmetry-of-revolution form, the configuration of a mold base material is not necessarily limited to a symmetry-of-revolution form. For example, as long as the front face in which an optical functional side is formed is the symmetry of revolution, about configurations other than the part in which optical functional sides, such as other parts of a mold base material, for example, the periphery section of a shaping side, a neck of a mold, or spittle, are formed, you may be rotation unsymmetrical forms, such as a rectangle cross section. [0064] furthermore — although the configuration of the front faces 1a, 3, 21, and 30a of a mold or a protective coat is symmetrical to a Y-axis in each above-mentioned

operation gestalt respectively — this invention — a shaft — it is applicable in order to form an unsymmetrical optical functional side. The configuration of masks 4 and 33 and the mask fixtures 7 and 35 is not limited to the operation gestalt which carried out [above-mentioned] illustration, but just covers an etching particle or a membrane formation particle.

[0065]

[Effect of the Invention] As mentioned above, the manufacture approach of the optical element of this invention possesses the process which arranges an optical material between the molds of a pair, the process which heats an optical material and a mold to predetermined temperature, and the process which presses a mold in order to imprint the configuration of a mold on the front face of an optical material, and the 1st [at least] page of a mold is rotation asymmetry. According to this approach, since the rotation unsymmetrical configuration of a mold is imprinted on the surface of an optical element, it becomes possible to mass-produce the optical element which has the same optical engine performance.

[0066] moreover, since the rotation unsymmetrical configuration of a mold is formed etching into an ununiformity the front face symmetrical with rotation of a protective coat established in a mold base material or its front face, or by making an ununiformity deposit the film on a front face symmetrical with rotation of a mold base material, it is special — manufacture of a mold becomes easy, without **(ing) and using an expensive processing machine. Moreover, the mold base material which has a configuration symmetrical with rotation can be easily formed in a front face by the conventional cutting or the grinding approach. Furthermore, in etching processing or membrane formation processing, since the etching rate or the membrane formation rate is stable, the amount of processings is easily controllable. So, the rotation unsymmetrical configuration of a mold can be formed correctly, without spoiling the symmetry-of-revolution configuration of the beginning of a mold base material.

[0067] Moreover, the process which arranges a mask in the location which separated the rotation unsymmetrical configuration of a mold upwards from the front-face top of a mold base material etc. symmetrical with rotation, or the front face symmetrical with rotation, [whether it forms in the front face of a mold base material etc. symmetrical with rotation through a mask by dry etching processing which has the process which irradiates ion or a radical, and] Or the process which forms the resist film in the front face of a mold base material etc. symmetrical with rotation except the part of the predetermined configuration which should be etched at least, By forming by wet etching processing which has the process which dips the front face of a mold base material etc. symmetrical with rotation into an etching reagent at least, the etching processing technique currently performed conventionally is applicable. consequently — without it newly uses special equipment and a special technique — comparatively — easy — rotation — an unsymmetrical mold can be obtained.

[0068] In the approach of making an ununiformity depositing the film on a front face symmetrical with rotation of the above-mentioned mold base material moreover, the rotation unsymmetrical configuration of a mold The process which arranges a mask in the location upwards distant from the front-face top symmetrical with rotation of a mold, or the front face symmetrical with rotation, The sputtering method for having the process which irradiates a particle on a front face symmetrical with rotation of a mold base material, PVD (physical vapor deposition) — law and CVD (chemical vapor deposition) — the membrane formation technique which be chosen from law and which shifts, can form by that approach and is performed conventionally is applicable. Especially, by the conventional approach, manufacture becomes possible [forming difficult toric side or cylindrical side on the surface of a mold]. Furthermore, many molds can be formed in coincidence by etching processing or membrane formation processing. So, time amount which formation per mold takes can be shortened, and the cost per mold can be reduced.

[0069] Moreover, in the approach of forming the film in the front face of a mold base material, or it etches the front face of a mold base material through a mask, the optical functional side of a mold base material can be formed in a desired configuration by adjusting the location of the optical functional side over the optical functional side of the configuration of opening of a mask, and/or a mold base material. furthermore — without the forming-membranes method can be applied to the formation process of the protective coat to the optical functional side of a mold, or the mold release film currently performed from the former and it increases the number of production processes of a mold — rotation — an unsymmetrical mold can be formed.

[0070] furthermore, rotation of a mold — an unsymmetrical configuration — this rotation — since it is constituted so that shaft top wave aberration may be made to generate an astigmatism component when an unsymmetrical configuration is imprinted by the optical element, the wave aberration on a shaft can be made, as for optical elements, such as an aspheric lens which has at least one rotation unsymmetrical optical functional side manufactured by the above-mentioned approach, to generate an astigmatism component So, the optical element which generates the astigmatism of the almost same amount as the almost same direction can be mass-produced.

[0071] Moreover, it can equip with an optical element easily by positioning the mark to the position of optical equipment by detecting the direction of the astigmatism generated by the rotation unsymmetrical optical functional side of an optical element, and carrying out marking of the direction of an optical element (clinging). So, it is omissible to adjust the direction of the optical element to an optical axis, acting as the monitor of the astigmatism. Furthermore, if the shape of toothing corresponding to a mark is formed in the edge part of a mold, a mark can be formed in manufacture and coincidence of an optical element at the edge section of an optical element. so, rotation — detection of the direction of the astigmatism generated by the unsymmetrical optical functional side is omissible.

[Translation done.]

TECHNICAL FIELD

[Field of the Invention] This invention relates to the manufacture approach of the rotation asymmetrical type suitable for the manufacture approach of optical elements, such as an aspheric lens used for an optical instrument, and it.

[Translation done.]

PRIOR ART

[Description of the Prior Art] Generally, the optical head for an optical disk or magneto-optic disks is always driven to radial [of a disk], in order to carry out the tracking of the recording surface top of a disk. Therefore, in almost all cases, the data on the recording surface of a disk are read, or although data are written in on a recording surface, the field outside a shaft of an objective lens is used. However, since astigmatism increases in the field outside a shaft, the optical-character ability of the lens in the field outside a shaft is inferior as compared with the optical-character ability in a paraxial field. Furthermore, the light from the semiconductor laser used as the light source has the astigmatic difference. Moreover, the 2nd lens for condensing to a photodetector the light reflected by the recording surface of a disk also has astigmatism. Therefore, the record reproducibility ability of an optical head will deteriorate further.
[0003] Therefore, various approaches are proposed in order to raise the engine performance of an optical head. as the 1st conventional example — JP,5-107467,A — at least — rotation — the objective lens which has an unsymmetrical optical functional side is proposed. The aberration on an optical axis can be made to generate an astigmatism component by forming the optical functional side of an objective lens in rotation asymmetry. The direction of an objective lens is adjusted so that aberration with the above-mentioned semiconductor laser or the 2nd lens may be made to offset by the astigmatism generated by the rotation unsymmetrical side. Moreover, the method of grinding an optical material directly and processing it as 2nd conventional example, is learned.
[0004] As 3rd conventional example, the manufacturing technology of the optical element by press forming is proposed by U.S. Pat. No. 5,015,280. The press-forming approach is a method of construction which imprints a mold configuration for an optical material. So, if a mold is processible with high precision, a desired optical element can be manufactured easily. When the optical element which should be manufactured is the symmetry of revolution like a symmetry-of-revolution aspheric lens, a mold can be formed using an ultraprecise CNC control machine tool. A mold rotates an optical axis as a core and feed motion of grinding or the cutting tool is carried out by the locus of the non-radii used as the cross-section configuration of a lens. Thereby, a mold can be manufactured comparatively easily in the configuration precision of about 0.1 micrometers.
[0005] The method of making for example, a JP,5-107467,A official report generate astigmatism by controlling a process condition, using the mold of a symmetry-of-revolution configuration as 4th conventional example is proposed.

[Translation done.]

EFFECT OF THE INVENTION

[Effect of the Invention] As mentioned above, the manufacture approach of the optical element of this invention possesses the process which arranges an optical material between the molds of a pair, the process which heats an optical material and a mold to predetermined temperature, and the process which presses a mold in order to imprint the configuration of a mold on the front face of an optical material, and the 1st [at least] page of a mold is rotation asymmetry. According to this approach, since the rotation unsymmetrical configuration of a mold is imprinted on the surface of an optical element, it becomes possible to mass-produce the optical element which has the same optical engine performance.
[0066] moreover, since the rotation unsymmetrical configuration of a mold is formed etching into an ununiformity the front face symmetrical with rotation of a protective coat established in a mold base material or its front face, or by making an ununiformity deposit the film on a front face symmetrical with rotation of a mold base material, it is special — manufacture of a mold becomes easy, without **(ing) and using an expensive processing machine. Moreover, the mold base material which has a configuration symmetrical with rotation can be easily formed in a front face by the conventional cutting or the grinding approach. Furthermore, in etching processing or membrane formation processing, since the etching rate or the membrane formation rate is stable, the amount of processings is easily controllable. So, the rotation unsymmetrical configuration of a mold can be formed correctly, without spoiling the symmetry-of-revolution configuration of the beginning of a mold base material.
[0067] Moreover, the process which arranges a mask in the location which separated the rotation unsymmetrical configuration of a mold upwards from the front-face top of a mold base material etc. symmetrical with rotation, or the front face symmetrical with rotation, [whether it forms in the front face of a mold base material etc. symmetrical with rotation through a mask by dry etching processing which has the process which irradiates ion or a radical, and] Or the process which forms the resist film in the front face of a mold base material etc. symmetrical with rotation except the part of the predetermined configuration which should be etched at least, By forming by wet etching processing which has the process which dips the front face of a mold base material etc. symmetrical with rotation into an etching reagent at least, the etching processing technique currently performed conventionally is applicable. consequently — without it newly uses special equipment and a special technique — comparatively — easy — rotation — an unsymmetrical mold can be obtained.
[0068] Moreover, it sets to the approach of making an ununiformity depositing the film on a front face symmetrical with rotation of the above-mentioned mold base material, and is the rotation unsymmetrical configuration of a mold, the sputtering method for having the process which arranges a mask in the location upwards distant from the front-face top symmetrical with rotation of a mold, or the front face symmetrical with rotation, and the process which irradiates a particle on a front face symmetrical with rotation of a mold base material, and PVD (physical vapor deposition) — law and CVD (chemical vapor deposition) — the membrane-formation technique which chooses from law and which shifts, can form by that approach and is performed conventionally is applicable Especially, by the conventional approach, manufacture becomes possible [forming difficult toric side or cylindrical side on the surface of a mold]. Furthermore, many molds can be formed in coincidence by etching processing or membrane formation processing. So, time amount which formation per mold takes can be shortened, and the cost per mold can be reduced.
[0069] Moreover, in the approach of forming the film in the front face of a mold base material, or it etches the front face of a mold base material through a mask, the optical functional side of a mold base material can be formed in a desired configuration by adjusting the location of the optical functional side over the optical functional side of the configuration of opening of a mask, and/or a mold base material. furthermore — without the forming-membranes method can be applied to the formation process of the protective coat to the optical functional side of a mold, or the mold release film currently performed from the former and it increases the number of production processes of a mold — rotation — an unsymmetrical mold can be formed.
[0070] furthermore, rotation of a mold — an unsymmetrical configuration — this rotation — since it is constituted so that shaft top wave aberration may be made to generate an astigmatism component when an unsymmetrical configuration is imprinted by the optical element, the wave aberration on a shaft can be made, as for optical elements, such as an aspheric lens which has at least one rotation unsymmetrical optical functional side manufactured by the above-mentioned approach, to generate an astigmatism component So, the optical element which generates the astigmatism of the almost same amount as the almost same direction can be mass-produced.
[0071] Moreover, it can equip with an optical element easily by positioning the mark to the position of optical equipment by detecting the direction of the astigmatism generated by the rotation unsymmetrical optical functional

side of an optical element, and carrying out marking of the direction of an optical element (clinging). So, it is omissible to adjust the direction of the optical element to an optical axis, acting as the monitor of the astigmatism. Furthermore, if the shape of toothing corresponding to a mark is formed in the edge part of a mold, a mark can be formed in manufacture and coincidence of an optical element at the edge section of an optical element. so, rotation — detection of the direction of the astigmatism generated by the unsymmetrical optical functional side is omissible.

[Translation done.]

TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention] however, the conventional example of the above 1st — like — rotation -- it is very difficult as a practical question to manufacture an unsymmetrical optical element. in order [moreover,] to make an optical material and grinding stones, such as glass, rock mutually and to adjust each other and grind them by the direct grinding method which is the 2nd conventional example — inevitable — a flat surface — or only a spherical-surface configuration is processible. Therefore, by the conventional direct grinding method, it has the trouble that the optical element of a rotation unsymmetrical configuration cannot be manufactured.
[0007] the optical element which should be manufactured in the 3rd conventional example — rotation — when it has an unsymmetrical optical functional side, the processing machine which manufactures a mold is very complicated, and becomes an expensive highly precise and thing. That is, it must carry out during 1 rotation of a mold or a main shaft repeatedly, controlling advance retreat of a tool with high precision, attaching an encoder in the main shaft of a processing machine, and measuring angle of rotation of a mold, in order to detect angle of rotation of a mold, for example. Furthermore, it is difficult to secure the configuration precision of the mold formed of this processing. Moreover, in order to make the location of a tool follow rotation of a mold or a main shaft, a main shaft must be rotated very slowly, and it has the trouble that the floor to floor time of a mold will become long.
[0008] In the 4th conventional example, control management of molding temperature, a temperature gradient, compacting pressure, the shaping material configuration, etc. must be carried out with high precision. Furthermore, it has the trouble that it is difficult to secure the yield in the mass production of an optical element, and the direction of the astigmatism of a lens does not become settled.
[0009] As mentioned above, it was difficult to manufacture the optical element of a rotation unsymmetrical configuration by the conventional manufacture approach. The purpose of this invention is offering the manufacture approach of the mold suitable for the approach and it which manufacture easily the optical element which has the optical functional side of a nonrotation symmetry configuration.

[Translation done.]

MEANS

[Means for Solving the Problem] In order to attain the above-mentioned purpose, the manufacture approach of the optical element of this invention Arrange an optical material between the molds of a pair and said optical material and said mold are heated to predetermined temperature. It is the manufacture approach of the optical element which imprints the configuration of said type of optical functional side on the front face of said optical material by pressing said mold. Said type of at least one optical functional side is rotation asymmetry, and said rotation unsymmetrical configuration is formed by etching a field symmetrical with rotation of a mold base material into an ununiformity.
[0011] In the above-mentioned configuration, said type of rotation unsymmetrical configuration is formed by the dry etching method, it is in the condition which has arranged the mask in the location separated from the location adjacent to the symmetry-of-revolution front face of said mold base material, or the front face for rotation to the upper part, and, as for said dry etching method, it is desirable to carry out by irradiating an ion beam or a radical beam on the symmetry-of-revolution front face of said mold base material.
[0012] Or in the above-mentioned configuration, it is desirable to carry out by forming said type of rotation unsymmetrical configuration by the wet etching method, and said wet etching method's forming the resist film in the symmetry-of-revolution front face of said mold base material at least except for the part of the predetermined configuration which should be etched, and dipping the symmetry-of-revolution front face of said mold base material in an etching solution at least.
[0013] In each above-mentioned configuration, it is desirable that said type of rotation unsymmetrical configuration is a toric side or a cylindrical side. Moreover, in each above-mentioned configuration, when said rotation unsymmetrical configuration is imprinted by the optical element, it is desirable that it is the configuration which produces the astigmatism component of shaft top wave aberration. Moreover, in each above-mentioned configuration, it is desirable to form a protective coat in said type of rotation unsymmetrical front face at homogeneity.
[0014] On the other hand, the manufacture approach of another optical element of this invention arranges an optical material between the molds of a pair. It is the manufacture approach of the optical element which imprints the configuration of said type of optical functional side on the front face of said optical material by heating said optical material and said mold to predetermined temperature, and pressing said mold. Said type of at least one optical functional side is rotation asymmetry, and said rotation unsymmetrical configuration is formed by etching into an ununiformity a field symmetrical with rotation of the protective coat formed on the mold base material.
[0015] In the above-mentioned configuration, said type of rotation unsymmetrical configuration is formed by the dry etching method, it is in the condition which has arranged the mask in the location separated from the location adjacent to the symmetry-of-revolution front face of the protective coat on said mold base material, or the front face for rotation to the upper part, and, as for said dry etching method, it is desirable to carry out by irradiating an ion beam or a radical beam on the symmetry-of-revolution front face of said protective coat.
[0016] Or in the above-mentioned configuration, it is desirable to carry out by forming said type of rotation unsymmetrical configuration by the wet etching method, and said wet etching method's forming the resist film in the symmetry-of-revolution front face of the protective coat formed in the front face of said mold base material at least except for the part of the predetermined configuration which should be etched, and dipping the symmetry-of-revolution front face of said mold base material in an etching solution at least.
[0017] In each above-mentioned configuration, it is desirable that said type of rotation unsymmetrical configuration is a toric side or a cylindrical side. Moreover, in each above-mentioned configuration, when said rotation unsymmetrical configuration is imprinted by the optical element, it is desirable that it is the configuration which produces the astigmatism component of shaft top wave aberration.
[0018] Moreover, the manufacture approach of still more nearly another optical element of this invention Arrange an optical material between the molds of a pair and said optical material and said mold are heated to predetermined temperature. It is the manufacture approach of the optical element which imprints the configuration of said type of optical functional side on the front face of said optical material by pressing said mold. Said type of at least one optical functional side is rotation asymmetry, and said rotation unsymmetrical configuration is formed by forming the film to an ununiformity on the symmetry-of-revolution front face of a mold base material.
[0019] the above-mentioned configuration -- setting -- said type of rotation unsymmetrical configuration -- the sputtering method and PVD (physical vapor deposition) -- law and CVD (chemical vapor deposition) -- it shifts and it is formed by that approach, and it is in the condition which has arranged in the location which separated from the

location where said approach touches the symmetry-of-revolution side of said mold base material in a mask or the symmetry-of-revolution side chosen from law to the upper part, and it is desirable to carry out by irradiating a particle in the symmetry-of-revolution side of said mold base material

[0020] Moreover, in each above-mentioned configuration, it is desirable that said type of rotation unsymmetrical configuration is a toric side or a cylindrical side. Moreover, in each above-mentioned configuration, when said rotation unsymmetrical configuration is imprinted by the optical element, it is desirable that it is the configuration which produces the astigmatism component of shaft top wave aberration.

[0021] On the other hand, the manufacture approach of the rotation asymmetrical type for optical element shaping of this invention is arranged in the location which separated the mask from the location adjacent to the symmetry-of-revolution front face of a mold base material, or the front face for rotation to the upper part, and etches the symmetry-of-revolution front face of said mold base material into an ununiformity by irradiating an ion beam or a radical beam on the symmetry-of-revolution front face of said mold base material.

[0022] Moreover, except for the part of the predetermined configuration which should be etched, the manufacture approach of another rotation asymmetrical type for optical element shaping of this invention forms the resist film in the symmetry-of-revolution front face of a mold base material at least, and etches the symmetry-of-revolution front face of said mold base material into an ununiformity by dipping the symmetry-of-revolution front face of said mold base material in an etching solution at least.

[0023] The manufacture approach of still more nearly another rotation asymmetrical type for optical element shaping of this invention is arranged in the location which separated the mask from the location adjacent to the symmetry-of-revolution front face of the protective coat formed on the mold base material, or the front face for rotation to the upper part, and etches the symmetry-of-revolution front face of said protective coat into an ununiformity by irradiating an ion beam or a radical beam on the symmetry-of-revolution front face of said protective coat.

[0024] The manufacture approach of still more nearly another rotation asymmetrical type for optical element shaping of this invention forms the resist film in the symmetry-of-revolution front face of the protective coat formed on the mold base material at least except for the part of the predetermined configuration which should be etched, and etches the symmetry-of-revolution front face of said protective coat into an ununiformity by dipping the symmetry-of-revolution front face of said protective coat in an etching solution at least.

[0025] In each above-mentioned configuration, it is desirable that said type of rotation unsymmetrical configuration is a toric side or a cylindrical side. Moreover, in each above-mentioned configuration, when said rotation unsymmetrical configuration is imprinted by the optical element, it is desirable that it is the configuration which produces the astigmatism component of shaft top wave aberration.

[0026] The manufacture approach of still more nearly another rotation asymmetrical type for optical element shaping of this invention forms the film to an ununiformity on the symmetry-of-revolution front face of a mold base material. the above-mentioned configuration — setting — said type of rotation unsymmetrical configuration — the sputtering method and PVD (physical vapor deposition) — law and CVD (chemical vapor deposition) — it shifts and it is formed by that approach, and it is in the condition which has arranged in the location which separated from the location where said approach touches the symmetry-of-revolution side of said mold base material in a mask or the symmetry-of-revolution side chosen from law to the upper part, and it is desirable to carry out by irradiating a particle in the symmetry-of-revolution side of said mold base material Moreover, in each above-mentioned configuration, it is desirable that said type of rotation unsymmetrical configuration is a toric side or a cylindrical side. Moreover, in each above-mentioned configuration, when said rotation unsymmetrical configuration is imprinted by the optical element, it is desirable that it is the configuration which produces the astigmatism component of shaft top wave aberration.

[0027] Furthermore, when etching a mold base material directly, it is desirable to form a protective coat in said type of rotation unsymmetrical front face at homogeneity.

[0028]

[Embodiment of the Invention]

(1st operation gestalt) The 1st operation gestalt of the manufacture approach of the mold suitable for the manufacture approach of the optical element of this invention and it is explained, referring to drawing 5 , drawing 12 , and drawing 13 from drawing 1 . The optical element 50 which should be manufactured by the approach of this invention is an aspheric lens, and is shown in drawing 12 . The optical functional side 51 of an optical element 50 is the rotation unsymmetrical aspheric surface, and has perpendicular **** 52 and level **** 53. It differs from vertical radius of curvature and horizontal radius of curvature. So, **** 52 and 53 connects a focus to two different points, respectively. An optical element 50 has astigmatism on the shaft. An optical element 50 is manufactured by carrying out press molding of the optical material arranged between the molds of a pair. At least, one of the molds has the rotation unsymmetrical aspheric surface, and the rotation unsymmetrical aspheric surface is imprinted by the front face of an optical material. So, the optical functional side 51 of an optical element 50 is formed.

[0029] Next, the manufacture approach of a mold of having the rotation unsymmetrical aspheric surface is explained. As shown in drawing 1 , the middle assembly object 100 possesses the mold base material 1, and a mask 4 and the mask fixture 7. A tungsten (W) and the carbon (C) of the mold base material 1 are made of the cemented carbide used as a principal component. In order to prevent the welding of a blemish and the optical material at the time of shaping on the front face of a mold, a protective coat 2 may be formed on surface 1a of the mold base material 1. The mask 4 is arranged in the location which only predetermined distance separated from the front face 3 of

surface 1a of the mold base material 1, or a protective coat 2 up through the mask fixture 7. The argon (Ar) ion beam 6 is caudad irradiated from the upper part of a mask 4, in order to etch the front face 3 of surface 1a of the mold base material 1, or a protective coat 2. The mold base material 1 serves as a mold which has the rotation unsymmetrical aspheric surface, when a mold production process is completed.
[0030] The aspheric surface symmetrical with rotation is beforehand formed in surface 1a of the mold base material 1 by the approach for forming the conventional symmetry-of-revolution aspheric surface. The mold base material 1 rotates as a core the shaft corresponding to the optical axis of the optical element which should be manufactured. And feed motion of the grinding stone is carried out so that the processing point that a grinding stone and a mold base material touch may draw the predetermined direction of an optical element 50, for example, the cross-section configuration of non-radii where **** 52 of drawing 12 was met. The configuration precision of the mold base material 1 processed by this processing method was about **0.1 micrometers. When forming a protective coat 2 in surface 1a of the mold base material 1, protective coats, such as a platinum-iridium (Pt-Ir) alloy, are formed by 3 micrometers in thickness by the spatter.
[0031] The slash section is a part covered with the mask 4 of the mold base material 1 so that clearly from drawing 2 . For example, the diameter of the shaping side of the mold base material 1 including the edge section is 5mm, and surface 1a or the diameter of 3 is 4mm. The magnitude of the rectangle opening 5 is 5mmx2mm, and each opening 5 sets spacing of 1mm, and is arranged in parallel.
[0032] Next, it arranges to the etching system which shows the above-mentioned middle assembly object 100 shown in drawing 1 to drawing 4 . With the 1st operation gestalt, the ECR (electron cyclotron resonance) ion beam etching system is used. An etching system possesses an etching chamber 9, the stage 10 where it is equipped with the middle assembly object 100, the ion beam accelerating electrode 11 prepared in the upper limit section of an etching chamber 9, and the ion gun 13 formed on the etching chamber 9.
[0033] If a stage 10 is equipped with the middle assembly object 100, air will be removed so that the interior of an etching chamber 9 may serve as a vacuum. Then, argon (Ar) gas is introduced in an ion gun 13 through the gas installation bulb 14, and the plasma 12 is generated. The ion accelerating electrode 11 pulls out Ar ion from the plasma 12, and irradiates an ion beam 6 at the middle assembly object 100. The atom or molecule of a front face 3 of surface 1a of the mold base material 1 or a protective coat 2 is flipped off by the collision of the ion which has come flying. Thereby, surface 1a of the mold base material 1 or etching processing of the front face 3 of a protective coat 2 is performed.
[0034] In the 1st operation gestalt, the diameter at the maximum equator of the middle assembly object 100 was 15mm. It equipped with seven middle assembly objects 100 on the stage 10 in an etching chamber 9. The diameter of the ion beam bundle from an ion gun 13 was 60mm. The mask 4 was separated from the front face 3 of surface 1a of the mold base material 1, or a protective coat 2 10mm. The etching conditions are as follows. They were acceleration voltage 800V of the pressure of 0.09Pa of introductory Ar gas, and an ion beam 6, current density 1.0 mA/cm2 of an ion beam 6, and irradiation time 3 minutes of an ion beam 6.
[0035] The time amount which processing per mold took was about 90 minutes (1 hour, a half) including the time amount which lengthens air, in order to make into a vacuum the interior of the assembly time amount of the middle assembly object 100, the time amount which sets the middle assembly object 100 in an etching chamber 9, and an etching chamber 9. If the diameter of an ion beam bundle can be enlarged further, many molds can be manufactured efficiently.
[0036] It measured to the X-axis and Y shaft orientations which show the cross-section configuration of the mold formed as mentioned above to drawing 2 and drawing 3 . A measurement result is shown in drawing 5 . the rotation after a configuration with an axis of ordinate symmetrical with the rotation before [in / in drawing 5 , an axis of abscissa expresses the distance from a mold core to point of measurement, and / point of measurement] etching, and etching — the core of a mold is expressed for the amount of gaps with an unsymmetrical configuration as 0. Since the field in alignment with the Y-axis of the front face 3 of surface 1a of the mold base material 1 or a protective coat 2 is etched into homogeneity by ****** and the ion beam 6 with a mask 4 so that clearly from drawing 5 , the cross-section configuration of the mold of Y shaft orientations is not changing from a configuration symmetrical with the rotation before etching. On the other hand, since more fields which are distant from the core of a mold to X shaft orientations than a part for a core are exposed to an ion beam 6, the cross-section configuration of the mold of X shaft orientations inclines gently toward a periphery from the core. Consequently, the shape of surface 1a of the mold base material 1 after etching or surface type of the front face 3 of a protective coat 2 serves as rotation asymmetry like for example, a toric side. The overall radius of curvature of the mold of X shaft orientations becomes larger than the radius of curvature of the mold of Y shaft orientations.
[0037] Furthermore, another mold which has a front face symmetrical with rotation is beforehand prepared by the conventional approach. As shown in drawing 13 , the optical materials 60, such as glass and resin, are arranged among molds 61 and 62. Either of the molds 61 and 62 has the rotation unsymmetrical side formed by the above-mentioned etching approach, and another side has the symmetry-of-revolution side formed by the conventional approach. Molds 61 and 62 and the optical material 60 are heated by the predetermined temperature which the front face of the optical material 60 softens at least. Molds 61 and 62 are pressed by the predetermined pressure so that the shape of surface type of molds 61 and 62 may be imprinted by the front face of the optical material 60. then, molds 61 and 62 and the optical material 60 are cooled — having — rotation — the optical element 50 which is the aspheric lens which has the unsymmetrical optical functional side 51 is obtained.
[0038] In the 1st operation gestalt, the amount of the maximum gaps of the cross-section configuration of the mold

of X shaft orientations in the periphery section was set to 0.15 micrometers. The above-mentioned etching process was repeated 5 times, and 35 molds were manufactured in total. The configuration error of a mold was **0.02 micrometers to the amount of design gaps of 0.15 micrometers.

[0039] The press molding process was repeated and 1000 lenses were fabricated in the same mold. Optical-glass SF8 was used as an optical material. the optical element 50 cast using the above-mentioned mold — for example, rotation of a toric side etc. — since it has the unsymmetrical optical functional side 51, an optical element 50 generates astigmatism. When the optical-character ability of an optical element 50 was measured, each optical element 50 generated the astigmatism of the almost same amount as the almost same direction. The average value of astigmatism was 30mlambda (mlambda: 1/1000 of the wavelength of the light source used), and was a value moderate as an objective lens of the optical head for optical disk units. Moreover, the wave aberration of the optical element 50 whole was also good. The optical head was assembled using this optical element 50. The optical element 50 is attached so that the radial astigmatism outside a shaft of an optical disk may be offset by the shaft top astigmatism by the rotation unsymmetrical aspheric surface. The reproducing characteristics of the optical disk by the optical head using the optical element 50 of the 1st operation gestalt were superior to the reproducing characteristics using the conventional optical head which used the lens of the conventional symmetry-of-revolution configuration.

[0040] A desired rotation unsymmetrical configuration can be formed in a mold by controlling distance, etching conditions, and the amount of etching with the front face 3 of the surface 1a or the protective coat 2 of the configuration of the opening 5 of a mask 4, a mask 4, and the mold base material 1. The optical element which generates the astigmatism for which it asks by that cause can be obtained.

[0041] With the 1st operation gestalt, in order to etch the protective coat of a mold base material or its front face, argon ion was irradiated, but the same configuration can be acquired even if it is the dry etching method using other ion and radicals. Furthermore, although the protective coat 2 was formed in surface 1a of the mold base material 1 before etching processing and the front face 3 of a protective coat 2 was etched when a protective coat 2 was formed, before forming a protective coat 2, surface 1a of the mold base material 1 may be etched into rotation asymmetry, and the after protective coat 2 may be formed in homogeneity. Furthermore, you may etch the front face 3 of surface 1a of the mold base material 1, or a protective coat 2 by making an ion beam operate it (scanning), without using a mask.

[0042] (2nd operation gestalt) The 2nd operation gestalt of the manufacture approach of the mold suitable for the manufacture approach of the optical element of this invention and it is explained, referring to drawing 8 from drawing 6 . In the 2nd operation gestalt, the configuration of the optical element which should be manufactured, and the process process of the optical element using a mold are substantially [as the case of the 1st operation gestalt] the same. However, the manufacture approaches of a mold of having the rotation unsymmetrical aspheric surface differ.

[0043] As shown in drawing 6 , openings 23 and 24 are removed, and the whole surface of the mold base material 20 is ************ by the resist film 22. Opening 23 is formed so that the front face 21 of the mold base material 20 may be countered. The opening 24 for forming a mark is formed so that edge section 21a of a front face 21 may be countered. The mold base material 20 which has the resist film 22 is dipped in the etching solution 25. So, the front face 21 of the mold base material 20 is etched into a rotation unsymmetrical configuration. The mold base material 20 is made of chromium alloy stainless steel tool steel.

[0044] The front face 21 of the mold base material 20 is roughly formed in the symmetry-of-revolution aspheric surface configuration by the conventional approach. The electroless-nickel-plating film (not shown) is given to the front face 21 of the mold base material 20 at least. Furthermore, the nickel-plating film on the front face 21 of the mold base material 20 is cut by the diamond tool using an ultraprecise engine lathe. So, the symmetry-of-revolution aspheric surface is made to the nickel-plating film on the front face 21 on the mold base material 20 so that it may be correctly in agreement with the cross-section configuration of the optical element 50 in alignment with **** 52 shown in drawing 12 . The 5 time diluent of a sulfuric acid was used as an etching solution 25.

[0045] For example, the radius of the front face 21 of the mold base material 20 was 2mm, and the width of face of flat edge section 21a was 1mm. Therefore, the total radius of the molding side of the mold base material 20 containing the edge section was 3mm. All the front faces of the mold base material 20 except openings 23 and 24 are ************ by the resist film 22 so that it may not be etched with the etching solution 25. Opening 23 is arranged in accordance with the shaft Y shown in drawing 7 . The width of face of opening 23 was 1mm, and die length was about 4mm. Opening 24 is formed on Shaft Y and the shaft X which intersects perpendicularly. The diameter of opening 24 was 0.6mm.

[0046] The etching solution 25 is filled by glassware with a diameter of about 200mm, and is kept warm by 40 degrees C. The ******** type base material 20 was arranged in the cage of 40-piece ****** by the resist film of 16mm of diameters at the maximum equator, and it dipped in the etching solution 25 for 5 minutes. Then, the cage was pulled up from the etching reagent 25, and pure water washed. Consequently, the nickel-plating film on the front face 21 of the mold base material 20 was etched into rotation asymmetry.

[0047] It measured to the X-axis and Y shaft orientations which show the cross-section configuration of the mold formed by the above-mentioned approach to drawing 7 . A measurement result is shown in drawing 8 . the rotation after a configuration with an axis of ordinate symmetrical with the rotation before etching [in / in drawing 8 , an axis of abscissa expresses the distance from a mold core to point of measurement, and / point of measurement], and etching — the core of a mold is expressed for the amount of gaps with an unsymmetrical configuration as 0. Since a part for the core of Y shaft orientations of the nickel-plating film on the front face 21 of the mold base

material 20 is boiled with ************** and an etching reagent 25 by the resist film 22 and is etched more into homogeneity so that clearly from drawing 8 , the cross-section configuration of the mold of Y shaft orientations is not changing from a configuration symmetrical with the rotation before etching. On the other hand, since parts for many ************ and core of a mold are etched for the periphery of the nickel-plating film on the front face 21 of X shaft orientations by the etching reagent rather than a circumference part by the resist film 22, in the cross-section configuration of the mold of X shaft orientations, about 0.1 micrometers of circumference parts are high relatively to a part for a core. Furthermore, the depression is formed in the location which counters opening 24 in the part of -3 from the distance (radius) -2 of drawing 8 . Consequently, the configuration on the front face of a mold serves as rotation asymmetry like for example, a toric side. The radius of curvature of the mold of X shaft orientations becomes small relatively rather than the radius of curvature of the mold of Y shaft orientations.

[0048] When the configuration of 40 molds formed by the above-mentioned approach was measured, the configuration error of the cross-section configuration of the mold of X shaft orientations was within the limits of -0.02 to +0.03 micrometers to the amount of average gaps of 0.1 micrometers, and dispersion was small.

[0049] In addition, in order to prevent the welding of a blemish and the optical material on the front face of a mold at the time of molding of an optical element, the protective coat with a thickness of 2 micrometers was formed in the rotation unsymmetrical side of a mold for the protective coat of a platinum-tantalum (Pt-Ta) alloy by the sputtering method.

[0050] Furthermore, other molds which have the symmetry-of-revolution aspheric surface are prepared. The optical material 60 made of polycarbonate resin is arranged among molds 61 and 62 like the 1st operation gestalt shown in drawing 13 . Either of the molds 61 and 62 has the rotation unsymmetrical side formed by the above-mentioned etching approach, and another side has the symmetry-of-revolution side formed by the conventional approach. After heating the optical material 60 and molds 61 and 62 to predetermined temperature, molds 61 and 62 were pressed by the predetermined pressure. Then, the optical material 60 and molds 61 and 62 were cooled. Thus, the optical element 50 was obtained.

[0051] By repeating such a press molding process, 1000 lenses were fabricated in the same mold. Since the optical element 50 manufactured by press molding using the above-mentioned mold has the rotation unsymmetrical optical functional sides 51, such as a toric side, as shown in drawing 13 , an optical element 50 generates astigmatism. When the optical-character ability of an optical element 50 was measured, each optical element 50 generated the astigmatism of the almost same amount as the almost same direction. The average value of astigmatism was 25mlambda (mlambda: 1/1000 of the wavelength of the light source used), and was a value moderate as an objective lens of the optical head for optical disk units. Moreover, the wave aberration of the optical element 50 whole was also good. The optical head was assembled using this optical element 50. As shown in drawing 7 and drawing 8 , the optical element was positioned by detecting the mark which shows the direction of rotation asymmetry. With the 2nd operation gestalt, since it is not necessary to actually measure astigmatism, in case an optical head is equipped with an optical element 50, an optical element 50 can be easily attached in the direction which has the optimal optical-character ability. The reproducing characteristics of the optical disk by the optical head using the optical element 50 of the 2nd operation gestalt were superior to the reproducing characteristics using the conventional optical head using the lens fabricated with the mold of the conventional symmetry-of-revolution configuration.

[0052] A desired rotation unsymmetrical configuration can be formed in a mold by controlling the configuration, the etching conditions, and the amount of etching of opening 23 of the resist film 22. The optical element which generates the astigmatism for which it asks by that cause can be obtained. Furthermore, an etching process is not limited to the example shown in drawing 6 . Some mold base materials 20 including a front face 21 may be dipped in an etching solution. In this case, what is necessary is just to form the resist film 22 in about 21 front face of the mold base material 20. The component of the etching solution 25 just etches the ingredient of the mold base material 20. With the 2nd operation gestalt, in order to etch the nickel-plating film on the front face 21 of the mold base material 20, the sulfuric acid was used, but other things may be used as long as it can etch the protective coat of a mold base material or its front face. Moreover, although the nickel-plating film on the front face 21 of the mold base material 20 was etched with the 2nd operation gestalt, the front face 21 of the mold base material 20 may be etched directly.

[0053] (3rd operation gestalt) The 3rd operation gestalt of the manufacture approach of the mold suitable for the manufacture approach of the optical element of this invention and it is explained, referring to drawing 11 from drawing 9 . In the 3rd operation gestalt, the production process of the optical element using the optical element and mold which should be manufactured is substantially [as the 1st operation gestalt] the same. However, the manufacture approach of a mold of having the rotation unsymmetrical aspheric surface differs from the 1st operation gestalt. the 3rd operation gestalt — setting — rotation — the sputtering method is used as the formation approach of an unsymmetrical mold.

[0054] As shown in drawing 9 , the middle assembly object 200 possesses the mold base material 30, and a mask 33 and the mask fixture 35. The mask 33 is arranged through the mask fixture 35 above the mold base material 30. From the upper part of a mask 33, sputtered particles 36 go caudad, come flying, and form the film 31 in the front face of the mold base material 30. The alumina of the mold base material 30 is made of the cermet used as a principal component.

[0055] In advance of a sputtering process, the symmetry-of-revolution aspheric surface is formed in surface 30a of the mold base material 30 by the conventional approach. The shaft corresponding to the optical axis of optical elements, such as a rotation unsymmetrical aspheric lens which should have the mold base material 30 fabricated, is

rotated as a core. Feed motion of the grinding stone is carried out so that the processing point that a grinding stone and a mold base material touch may draw the non-radii cross-section configuration where the predetermined direction 52 of an optical element 50, for example, **** of drawing 12 , was met.
[0056] As shown in drawing 10 , the slash section is a part which has covered the mold base material 30 with the mask 33. For example, the diameter of surface 30a of the mold base material 30 was 6mm, and the magnitude of the rectangle opening 34 was 6mmx4mm. The distance of a mask 33 and surface 30a of the mold base material 30 was 5mm.
[0057] Next, 14 middle assembly objects 200 were arranged on the holder with a diameter [of a sputtering system] of about 100mm, the air inside a sputtering system was lengthened, and it was made the vacuum. Then, argon (Ar) gas was introduced in the sputtering system. The pressure of argon gas was set to 0.13Pa, and discharge was generated in RF power 100W. Sputtering was performed for 60 minutes by using Pt-Re as a target. Consequently, the film 31 which has uneven thickness was formed on surface 30a of the mold base material 30 so that it might become rotation asymmetry. With the 3rd operation gestalt, the ingredient of the film 31 is the platinum-rhenium (Pt-Re) alloy formed by the sputtering method. This film 31 functions also as a protective coat for preventing a blemish and the optical material welding at the time of shaping. The thickness of the film 31 in a part for the core of a mold was 2 micrometers. Moreover, the thickness of the film 31 in the location which is distant from the core of a mold 2.5mm to X shaft orientations was 1.87 micrometers. The amount of displacement of the cross-section configuration of the mold in X shaft orientations from a configuration symmetrical with the first rotation was 0.13 micrometers. the configuration error of a mold — an average — a variation rate — it was **0.02 micrometers to the amount of 0.13 micrometers.
[0058] The cross-section configuration of the mold of the X-axis and Y shaft orientations which are shown in drawing 10 was measured. A measurement result is shown in drawing 11 . In drawing 11 , an axis of abscissa expresses the distance from a mold core to point of measurement, and an axis of ordinate expresses the core of a mold for the amount of gaps of the configuration symmetrical with original rotation and the front face 32 of the film 31 which were formed on surface 30a of the mold base material 30 in point of measurement as 0. Since, as for a part for the core of surface 30a of the mold base material 30 in Y shaft orientations, ************** and the film 31 are formed on it with a mask 33 at homogeneity so that clearly from drawing 11 , the cross-section configuration of the mold of Y shaft orientations is not changing from the configuration of the beginning of surface 30a of the mold base material 30. On the other hand, since there are more amounts of the particle to which it adheres near the periphery section of the mold base material 30 in X shaft orientations near the core of surface 30a of ************ and the mold base material 30 with a mask 33 than the amount of the particle adhering to a periphery, the cross-section configuration of the mold in X shaft orientations turns into a configuration which inclines gently toward an outside from a core. Consequently, the shape of surface type of the mold corresponding to the front face 32 of the film 31 on the mold base material 30 serves as rotation asymmetry, such as for example, a toric side. The participation radius of curvature of X shaft orientations becomes larger than the radius of curvature of Y shaft orientations as a whole.
[0059] Furthermore, another mold which has the symmetry-of-revolution aspheric surface was prepared, and the optical material 60 made in optical-glass VC79 among molds 61 and 62 has been arranged like the 1st operation gestalt shown in drawing 13 . One side of molds 61 and 62 has the rotation unsymmetrical aspheric surface formed by the describing [above] sputtering method, and another side has the symmetry-of-revolution aspheric surface formed by the conventional approach. The optical material 60 and molds 61 and 62 were heated to predetermined temperature, and molds 61 and 62 were pressed by the predetermined pressure. Then, the optical material 60 and molds 61 and 62 were cooled. Thus, the optical element 50 was obtained.
[0060] Such a press molding process was repeated and 1000 optical elements were manufactured with the same mold. Since the optical element 50 cast with the above-mentioned mold has the rotation unsymmetrical optical functional sides 51, such as a toric side, an optical element 50 generates astigmatism. When the optical-character ability of an optical element 50 was measured, each optical element 50 generated the astigmatism of the almost same amount as the almost same direction. The average value of astigmatism was 25mlambda (mlambda: 1/1000 of the wavelength of the light source used), and was a value moderate as an objective lens of the optical head for optical disk units. Moreover, the wave aberration of the optical element 50 whole was also good. The optical head was assembled using this optical element 50. The optical element 50 is attached so that the radial astigmatism outside a shaft of a magneto-optic disk may be offset by the rotation unsymmetrical aspheric surface. The reproducing characteristics of the magneto-optic disk by the optical head using the optical element 50 of the 3rd operation gestalt were superior to the reproducing characteristics of the conventional optical head which used the lens of the conventional symmetry-of-revolution configuration.
[0061] A desired rotation unsymmetrical configuration can be formed in a mold by controlling the amount of the particle adhering to surface 30a of the configuration of the opening 34 of a mask 33, the distance of a mask 33 and surface 30a of the mold base material 30, sputtering conditions, and the mold base material 30 etc. The optical element which generates the astigmatism for which it asks by that cause can be obtained.
[0062] although the sputtering method was used as an approach of forming the film 31 with the 3rd operation gestalt — PVD (physical vapor deposition) — law and CVD (chemical vapor deposition) — law may be used. Moreover, although the film 31 which serves as a protective coat was formed in rotation asymmetry, an interlayer may be formed in rotation asymmetry and a protective coat may be formed on an interlayer at homogeneity.
[0063] In each above 1st, 2nd, and 3rd operation gestalten, as shown in each top view of drawing 2 , drawing 7 , and

drawing 10 , although the whole mold of the mold base materials 1, 20, and 30 is a symmetry-of-revolution form, the configuration of a mold base material is not necessarily limited to a symmetry-of-revolution form. For example, as long as the front face in which an optical functional side is formed is the symmetry of revolution, about configurations other than the part in which optical functional sides, such as other parts of a mold base material, for example, the periphery section of a shaping side, a neck of a mold, or spittle, are formed, you may be rotation unsymmetrical forms, such as a rectangle cross section.
[0064] furthermore -- although the configuration of the front faces 1a, 3, 21, and 30a of a mold or a protective coat is symmetrical to a Y-axis in each above-mentioned operation gestalt respectively -- this invention -- a shaft -- it is applicable in order to form an unsymmetrical optical functional side. The configuration of masks 4 and 33 and the mask fixtures 7 and 35 is not limited to the operation gestalt which carried out [above-mentioned] illustration, but just covers an etching particle or a membrane formation particle.

[Translation done.]

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] The sectional view showing the approach and middle assembly object which form the mold used in the 1st operation gestalt of the manufacture approach of the mold suitable for the manufacture approach of the optical element of this invention, and it
[Drawing 2] The top view of the middle assembly object shown in drawing 1 which shows the configuration and relative position of a mold base material and a mask in the 1st operation gestalt
[Drawing 3] The perspective view showing the configuration of the mold formed in the 1st operation gestalt
[Drawing 4] The flank sectional view showing the etching system used with the 1st operation gestalt in order to form a mold
[Drawing 5] The graph which shows the data corresponding to the shaft X of drawing 2 in the 1st operation gestalt, and drawing 3 , and the cross-section configuration of the mold after etching of the direction of Y
[Drawing 6] The flank sectional view showing how to form the mold used in the 2nd operation gestalt of the manufacture approach of the mold suitable for the manufacture approach of the optical element of this invention, and it
[Drawing 7] The top view of the midcourse phase of the mold base material in which the configuration and relative position of a mold base material and a mask in the 2nd operation gestalt are shown
[Drawing 8] The graph which shows the data corresponding to the shaft X of drawing 7 in the 2nd operation gestalt, and the cross-section configuration of the mold after etching of the direction of Y
[Drawing 9] The flank sectional view showing the approach and middle assembly object which form the mold used in the 3rd operation gestalt of the manufacture approach of the mold suitable for the manufacture approach of the optical element of this invention, and it
[Drawing 10] The top view of the middle assembly object shown in drawing 9 which shows the configuration and relative position of a mold base material and a mask in the 3rd operation gestalt
[Drawing 11] The graph which shows the data corresponding to the shaft X of drawing 10 in the 3rd operation gestalt, and the cross-section configuration of the mold after membrane formation of the direction of Y
[Drawing 12] The perspective view showing the optical element manufactured by the approach of this invention
[Drawing 13] The flank sectional view showing the press molding process of the manufacture approach of the optical element of this invention
[Description of Notations]
1 : Mold Base Material
1a: Mold base material front face
2 : Protective Coat
3 : Protective Coat Front Face
4 : Mask
5 : Rectangle Opening
6 : Ion Beam
7 : Mask Fixture
9 : Etching Chamber
10 : Stage
11 : Ion Beam Accelerating Electrode
12 : Plasma
13 : Ion Gun
14 : Introductory Bulb
20 : Mold Base Material
21 : Mold Base Material Front Face
22 : Resist Film
23 : Opening
24 : Opening
25 : Etching Reagent
30 : Mold Base Material
30a: Mold base material front face
31 : Film

32 : Film Front Face
33 : Mask
34 : Rectangle Opening
35 : Mask Fixture
36 : Sputtered Particles
50 : Optical Element
51 : Optical Functional Side
52 : ****
53 : ****
60 : Optical Material
61 : Mold
62 : Mold
100 : Middle Assembly Object
200 : Middle Assembly Object

[Translation done.]

* NOTICES *

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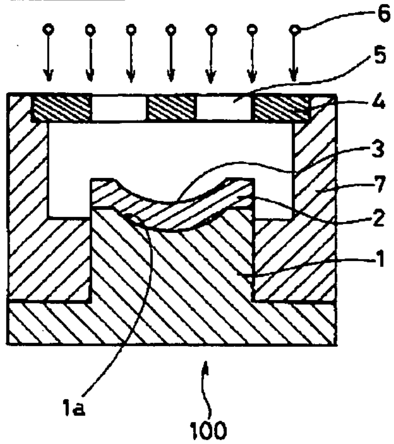
damages caused by the use of this translation.

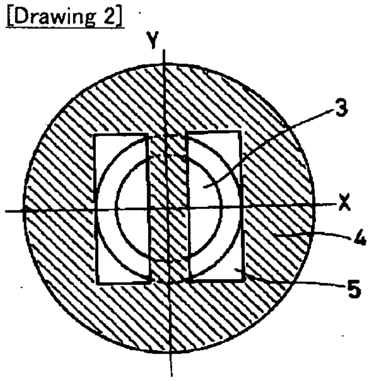
1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DRAWINGS

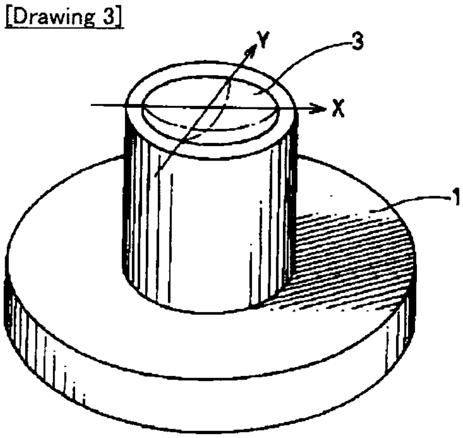
[Drawing 1]



[Drawing 2]



[Drawing 3]



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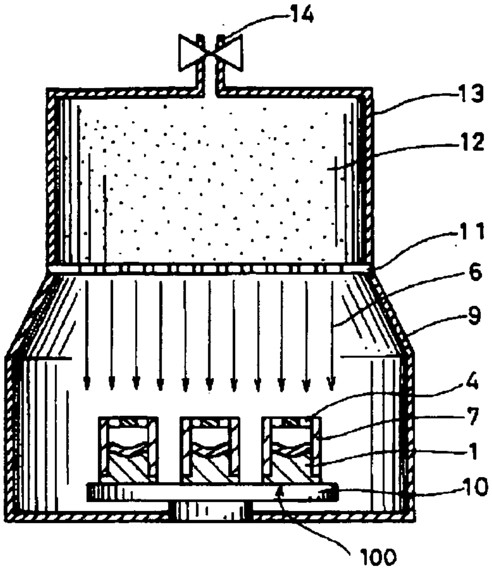

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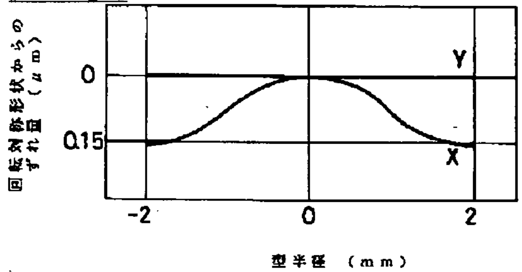

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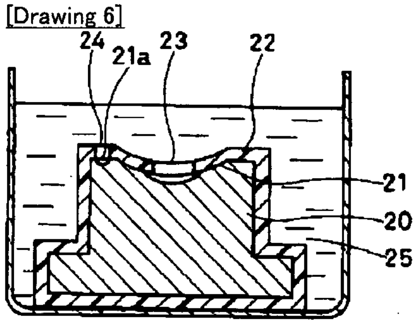
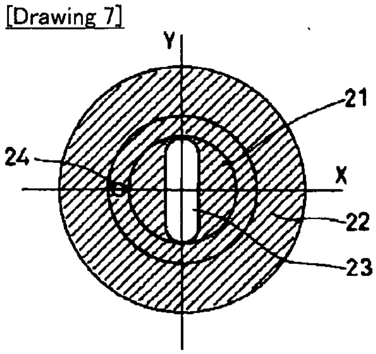
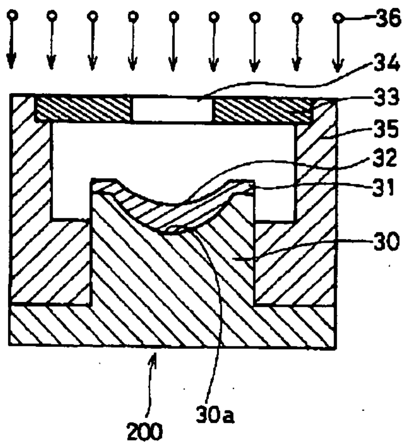


[Drawing 7]



[Drawing 9]



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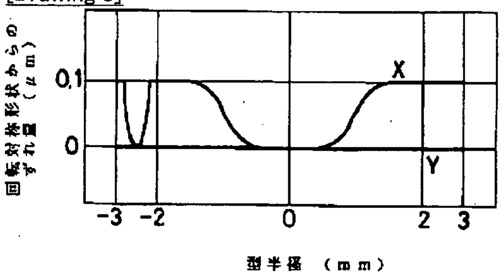
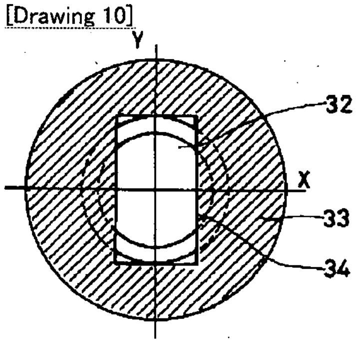


[Drawing 10]



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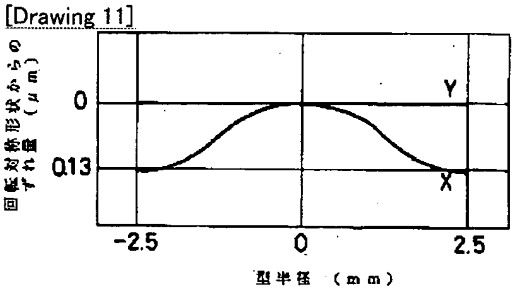
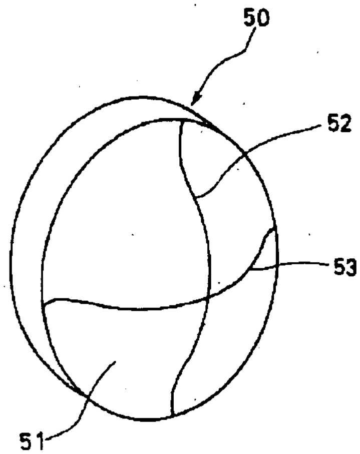
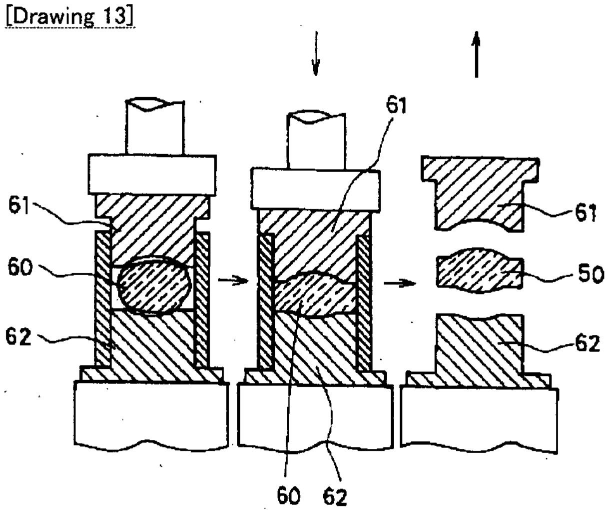


[Drawing 12]



[Drawing 13]



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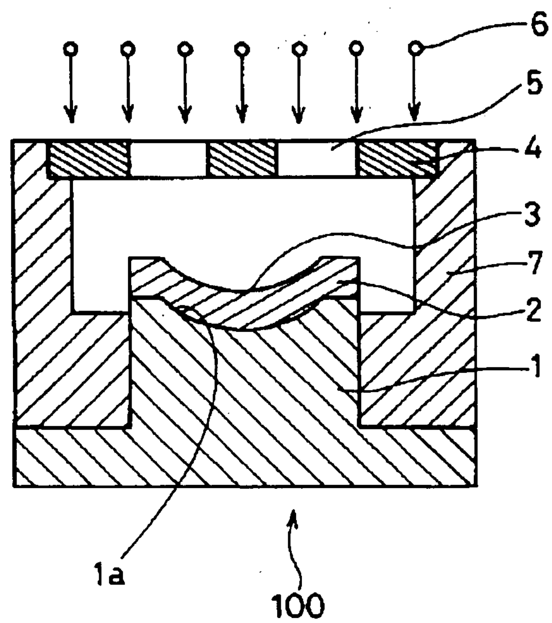
最終頁に続く

(54)【発明の名称】　光学素子の製造方法及び光学素子成形用回転非対称型の製造方法

(57)【要約】

【課題】　軸外非点収差を相殺するために軸上に非点収差を発生させるための、光学機能面の少なくとも１つに回転非対称形状を有する光ディスク装置の光ヘッド用の対物レンズ及びそれの製造に適する型を提供する。

【解決手段】　型母材１又はその上の保護膜２の回転対称表面１ａ又は３を不均一にエッチングし、回転非対処非球面型を製造し、その型を含む一対の型の間にガラスや樹脂等の光学素材を配置し、プレス成型して回転非対称非球面を有するレンズを製造する。



【特許請求の範囲】
【請求項１】　光学素材を一対の型の間に配置し、前記光学素材及び前記型を所定の温度に加熱し、前記型をプレスすることにより前記型の光学機能面の形状を前記光学素材の表面に転写する光学素子の製造方法であって、前記型の少なくとも１つの光学機能面は回転非対称であり、前記回転非対称形状は型母材の回転対称な面を不均一にエッチングすることにより形成される光学素子の製造方法。
【請求項２】　前記型の回転非対称形状はドライエッチング法により形成され、前記ドライエッチング法はマスクを前記型母材の回転対称表面に接する位置又は回転対象表面から上方に離れた位置に配置した状態で、前記型母材の回転対称表面にイオンビーム又はラジカルビームを照射することにより行う請求項１記載の光学素子の製造方法。
【請求項３】　前記型の回転非対称形状はウエットエッチング法により形成され、前記ウエットエッチング法はエッチングされるべき所定形状の部分を除いて少なくとも前記型母材の回転対称表面にレジスト膜を形成し、少なくとも前記型母材の回転対称表面をエッチング溶液に浸すことにより行う請求項１記載の光学素子の製造方法。
【請求項４】　前記型の回転非対称形状がトーリック面又はシリンドリカル面である請求項１から３のいずれかに記載の光学素子の製造方法。
【請求項５】　前記回転非対称形状は、光学素子に転写された際に、軸上波面収差の非点収差成分を生じる形状である請求項１から４のいずれかに記載の光学素子の製造方法。
【請求項６】　前記型の回転非対称表面に保護膜を均一に形成した請求項１から５のいずれかに記載の光学素子の製造方法。
【請求項７】　光学素材を一対の型の間に配置し、前記光学素材及び前記型を所定の温度に加熱し、前記型をプレスすることにより前記型の光学機能面の形状を前記光学素材の表面に転写する光学素子の製造方法であって、前記型の少なくとも１つの光学機能面は回転非対称であり、前記回転非対称形状は型母材上に形成された保護膜の回転対称な面を不均一にエッチングすることにより形成される光学素子の製造方法。
【請求項８】　前記型の回転非対称形状はドライエッチング法により形成され、前記ドライエッチング法はマスクを前記型母材上の保護膜の回転対称表面に接する位置又は回転対象表面から上方に離れた位置に配置した状態で、前記保護膜の回転対称表面にイオンビーム又はラジカルビームを照射することにより行う請求項７記載の光学素子の製造方法。
【請求項９】　前記型の回転非対称形状はウエットエッチング法により形成され、前記ウエットエッチング法はエッチングされるべき所定形状の部分を除いて、少なくとも前記型母材の表面に形成された保護膜の回転対称表面にレジスト膜を形成し、少なくとも前記型母材の回転対称表面をエッチング溶液に浸すことにより行う請求項７記載の光学素子の製造方法。
【請求項１０】　前記型の回転非対称形状がトーリック面又はシリンドリカル面である請求項７から９のいずれかに記載の光学素子の製造方法。
【請求項１１】　前記回転非対称形状は、光学素子に転写された際に、軸上波面収差の非点収差成分を生じる形状である請求項７から１０のいずれかに記載の光学素子の製造方法。
【請求項１２】　光学素材を一対の型の間に配置し、前記光学素材及び前記型を所定の温度に加熱し、前記型をプレスすることにより前記型の光学機能面の形状を前記光学素材の表面に転写する光学素子の製造方法であって、前記型の少なくとも１つの光学機能面は回転非対称であり、前記回転非対称形状は型母材の回転対称表面に膜を不均一に成膜することにより形成される光学素子の製造方法。
【請求項１３】　前記型の回転非対称形状は、スパッタリング法、ＰＶＤ(physical vapor deposition)法及びＣＶＤ(chemical vapor deposition)法から選択されたいずれかの方法により形成され、前記方法はマスクを前記型母材の回転対称面に接する位置又は回転対称面から上方に離れた位置に配置した状態で、前記型母材の回転対称面に粒子を照射することにより行う請求項１２記載の光学素子の製造方法。
【請求項１４】　前記型の回転非対称形状がトーリック面又はシリンドリカル面である請求項１２又は１３に記載の光学素子の製造方法。
【請求項１５】　前記回転非対称形状は、光学素子に転写された際に、軸上波面収差の非点収差成分を生じる形状である請求項１２から１４のいずれかに記載の光学素子の製造方法。
【請求項１６】　マスクを型母材の回転対称表面に接する位置又は回転対象表面から上方に離れた位置に配置し、前記型母材の回転対称表面にイオンビーム又はラジカルビームを照射することにより前記型母材の回転対称表面を不均一にエッチングする光学素子成形用回転非対称型の製造方法。
【請求項１７】　エッチングされるべき所定形状の部分を除いて、少なくとも型母材の回転対称表面にレジスト膜を形成し、少なくとも前記型母材の回転対称表面をエッチング溶液に浸すことにより前記型母材の回転対称表面を不均一にエッチングする光学素子成形用回転非対称型の製造方法。
【請求項１８】　マスクを型母材上に形成された保護膜の回転対称表面に接する位置又は回転対象表面から上方に離れた位置に配置し、前記保護膜の回転対称表面にイ

オンビーム又はラジカルビームを照射することにより前記保護膜の回転対称表面を不均一にエッチングする光学素子成形用回転非対称型の製造方法。

【請求項１９】　エッチングされるべき所定形状の部分を除いて、少なくとも型母材上に形成された保護膜の回転対称表面にレジスト膜を形成し、少なくとも前記保護膜の回転対称表面をエッチング溶液に浸すことにより前記保護膜の回転対称表面を不均一にエッチングする光学素子成形用回転非対称型の製造方法。

【請求項２０】　前記型の回転非対称形状がトーリック面又はシリンドリカル面である請求項１６から１９のいずれかに記載の光学素子成形用回転非対称型の製造方法。

【請求項２１】　前記回転非対称形状は、光学素子に転写された際に、軸上波面収差の非点収差成分を生じる形状である請求項１６ら２０のいずれかに記載の光学素子成形用回転非対称型の製造方法。

【請求項２２】　型母材の回転対称表面に膜を不均一に成膜する光学素子成形用回転非対称型の製造方法。

【請求項２３】　前記型の回転非対称形状は、スパッタリング法、ＰＶＤ(physical vapor deposition)法及びＣＶＤ(chemical vapor deposition)法から選択されたいずれかの方法により形成され、前記方法はマスクを前記型母材の回転対称面に接する位置又は回転対称面から上方に離れた位置に配置した状態で、前記型母材の回転対称面に粒子を照射することにより行う請求項２２記載の光学素子成形用回転非対称型の製造方法。

【請求項２４】　前記型の回転非対称形状がトーリック面又はシリンドリカル面である請求項２２又は２３に記載の光学素子成形用回転非対称型の製造方法。

【請求項２５】　前記回転非対称形状は、光学素子に転写された際に、軸上波面収差の非点収差成分を生じる形状である請求項２２から２４のいずれかに記載の光学素子成形用回転非対称型の製造方法。

【請求項２６】　前記型の回転非対称表面に保護膜を均一に形成した請求項１６又は１７に記載の光学素子成形用回転非対称型の製造方法。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は、光学機器に用いられる非球面レンズ等の光学素子の製造方法及びそれに適する回転非対称型の製造方法に関するものである。

【０００２】

【従来の技術】一般に、光ディスクや光磁気ディスク用の光ヘッドは、ディスクの記録面上をトラッキングするために、常にディスクの半径方向に駆動される。従って、ほとんどの場合、ディスクの記録面上のデータを読み出したり、記録面上にデータを書込むのに、対物レンズの軸外領域が使用される。しかしながら、軸外領域におけるレンズの光学性能は、軸外領域において非点収差が増加するため、近軸領域における光学性能と比較して劣っている。さらに、光源として用いられる半導体レーザーからの光は非点隔差を有する。また、ディスクの記録面により反射された光を光検出器に集光するための第２のレンズも非点収差を有する。そのため、光ヘッドの記録再生性能はさらに劣化してしまう。

【０００３】そのため、光ヘッドの性能を向上させるために種々の方法が提案されている。第１の従来例として、例えば特開平５－１０７４６７号公報には、少なくとも回転非対称な光学機能面を有する対物レンズが提案されている。対物レンズの光学機能面を回転非対称に形成することにより、光軸上の収差に非点収差成分を発生させることができる。対物レンズの方向は、回転非対称面により発生される非点収差により、上記半導体レーザや第２のレンズによる収差を相殺させるように調整される。また、第２の従来例として、光学素材を直接研磨して加工する方法が知られている。

【０００４】第３の従来例として、例えば米国特許第５，０１５，２８０号に、プレス成形による光学素子の製造技術が提案されている。プレス成形方法は、型形状を光学素材に転写する工法である。それゆえ、もし型を高精度に加工できれば、所望の光学素子を容易に製造することができる。製造されるべき光学素子が回転対称非球面レンズ等のように回転対称である場合、型は超精密ＣＮＣ制御工作機械を用いて形成することができる。型は光軸を中心として回転され、研削あるいは切削工具はレンズの断面形状となる非円弧の軌跡で送り運動される。これにより、約０．１μｍの形状精度で、比較的容易に型を製造することができる。

【０００５】第４の従来例として、例えば特開平５－１０７４６７公報には、回転対称形状の型を用いて、成形条件を制御することにより非点収差を発生させる方法が提案されている。

【０００６】

【発明が解決しようとする課題】しかしながら、上記第１の従来例のように回転非対称な光学素子を製造することは、実際問題として非常に困難である。また、第２の従来例である直接研磨法では、ガラス等の光学素材と砥石を相互に揺動させ、擦り合わせて研磨するため、必然的に平面かあるいは球面形状しか加工することができない。従って、従来の直接研磨法では、回転非対称形状の光学素子を製造することができないという問題点を有する。

【０００７】第３の従来例では、製造されるべき光学素子が回転非対称な光学機能面を有する場合、型を製作する加工機は非常に複雑で、高精度でかつ高価なものとなる。すなわち、例えば型の回転角度を検知するためにエンコーダを加工機の主軸に取り付け、型の回転角度を測定しながら、型又は主軸の１回転中に、工具の前進後退を高精度に制御しながら、繰り返し行わなければならな

い。さらに、この加工により形成された型の形状精度を確保することは困難である。また、工具の位置を型又は主軸の回転に追従させるために主軸を非常にゆっくりと回転させなければならず、型の加工時間が長くなってしまうという問題点を有する。

【０００８】第４の従来例では、成形温度、温度勾配、成形圧力、成形素材形状等を高精度に制御管理しなければならない。さらに、光学素子の量産において歩留まりを確保することは困難であり、また、レンズの非点収差の方向が定まらないという問題点を有する。

【０００９】以上のように、従来の製造方法では、回転非対称形状の光学素子を製造することは困難であった。本発明の目的は、非回転対称形状の光学機能面を有する光学素子を容易に製造する方法及びそれに適する型の製造方法を提供することである。

【００１０】

【課題を解決するための手段】上記目的を達成するため、本発明の光学素子の製造方法は、光学素材を一対の型の間に配置し、前記光学素材及び前記型を所定の温度に加熱し、前記型をプレスすることにより前記型の光学機能面の形状を前記光学素材の表面に転写する光学素子の製造方法であって、前記型の少なくとも１つの光学機能面は回転非対称であり、前記回転非対称形状は型母材の回転対称な面を不均一にエッチングすることにより形成される。

【００１１】上記構成において、前記型の回転非対称形状はドライエッチング法により形成され、前記ドライエッチング法はマスクを前記型母材の回転対称表面に接する位置又は回転対象表面から上方に離れた位置に配置した状態で、前記型母材の回転対称表面にイオンビーム又はラジカルビームを照射することにより行うことが好ましい。

【００１２】または、上記構成において、前記型の回転非対称形状はウエットエッチング法により形成され、前記ウエットエッチング法はエッチングされるべき所定形状の部分を除いて少なくとも前記型母材の回転対称表面にレジスト膜を形成し、少なくとも前記型母材の回転対称表面をエッチング溶液に浸すことにより行うことが好ましい。

【００１３】上記各構成において、前記型の回転非対称形状がトーリック面又はシリンドリカル面であることが好ましい。また、上記各構成において、前記回転非対称形状は、光学素子に転写された際に、軸上波面収差の非点収差成分を生じる形状であることが好ましい。また、上記各構成において、前記型の回転非対称表面に保護膜を均一に形成することが好ましい。

【００１４】一方、本発明の別の光学素子の製造方法は、光学素材を一対の型の間に配置し、前記光学素材及び前記型を所定の温度に加熱し、前記型をプレスすることにより前記型の光学機能面の形状を前記光学素材の表面に転写する光学素子の製造方法であって、前記型の少なくとも１つの光学機能面は回転非対称であり、前記回転非対称形状は型母材上に形成された保護膜の回転対称な面を不均一にエッチングすることにより形成される。

【００１５】上記構成において、前記型の回転非対称形状はドライエッチング法により形成され、前記ドライエッチング法はマスクを前記型母材上の保護膜の回転対称表面に接する位置又は回転対象表面から上方に離れた位置に配置した状態で、前記保護膜の回転対称表面にイオンビーム又はラジカルビームを照射することにより行うことが好ましい。

【００１６】または、上記構成において、前記型の回転非対称形状はウエットエッチング法により形成され、前記ウエットエッチング法はエッチングされるべき所定形状の部分を除いて、少なくとも前記型母材の表面に形成された保護膜の回転対称表面にレジスト膜を形成し、少なくとも前記型母材の回転対称表面をエッチング溶液に浸すことにより行うことが好ましい。

【００１７】上記各構成において、前記型の回転非対称形状がトーリック面又はシリンドリカル面であることが好ましい。また、上記各構成において、前記回転非対称形状は、光学素子に転写された際に、軸上波面収差の非点収差成分を生じる形状であることが好ましい。

【００１８】また、本発明のさらに別の光学素子の製造方法は、光学素材を一対の型の間に配置し、前記光学素材及び前記型を所定の温度に加熱し、前記型をプレスすることにより前記型の光学機能面の形状を前記光学素材の表面に転写する光学素子の製造方法であって、前記型の少なくとも１つの光学機能面は回転非対称であり、前記回転非対称形状は型母材の回転対称表面に膜を不均一に成膜することにより形成される。

【００１９】上記構成において、前記型の回転非対称形状は、スパッタリング法、ＰＶＤ(physical vapor deposition)法及びＣＶＤ(chemical vapor deposition)法から選択されたいずれかの方法により形成され、前記方法はマスクを前記型母材の回転対称面に接する位置又は回転対称面から上方に離れた位置に配置した状態で、前記型母材の回転対称面に粒子を照射することにより行うことが好ましい。

【００２０】また、上記各構成において、前記型の回転非対称形状がトーリック面又はシリンドリカル面であることが好ましい。また、上記各構成において、前記回転非対称形状は、光学素子に転写された際に、軸上波面収差の非点収差成分を生じる形状であることが好ましい。

【００２１】一方、本発明の光学素子成形用回転非対称型の製造方法は、マスクを型母材の回転対称表面に接する位置又は回転対象表面から上方に離れた位置に配置し、前記型母材の回転対称表面にイオンビーム又はラジカルビームを照射することにより前記型母材の回転対称表面を不均一にエッチングする。

【0022】また、本発明の別の光学素子成形用回転非対称型の製造方法は、エッチングされるべき所定形状の部分を除いて、少なくとも型母材の回転対称表面にレジスト膜を形成し、少なくとも前記型母材の回転対称表面をエッチング溶液に浸すことにより前記型母材の回転対称表面を不均一にエッチングする。

【0023】本発明のさらに別の光学素子成形用回転非対称型の製造方法は、マスクを型母材上に形成された保護膜の回転対称表面に接する位置又は回転対象表面から上方に離れた位置に配置し、前記保護膜の回転対称表面にイオンビーム又はラジカルビームを照射することにより前記保護膜の回転対称表面を不均一にエッチングする。

【0024】本発明のさらに別の光学素子成形用回転非対称型の製造方法は、エッチングされるべき所定形状の部分を除いて、少なくとも型母材上に形成された保護膜の回転対称表面にレジスト膜を形成し、少なくとも前記保護膜の回転対称表面をエッチング溶液に浸すことにより前記保護膜の回転対称表面を不均一にエッチングする。

【0025】上記各構成において、前記型の回転非対称形状がトーリック面又はシリンドリカル面であることが好ましい。また、上記各構成において、前記回転非対称形状は、光学素子に転写された際に、軸上波面収差の非点収差成分を生じる形状であることが好ましい。

【0026】本発明のさらに別の光学素子成形用回転非対称型の製造方法は、型母材の回転対称表面に膜を不均一に成膜する。上記構成において、前記型の回転非対称形状は、スパッタリング法、ＰＶＤ(physical vapor deposition)法及びＣＶＤ(chemical vapor deposition)法から選択されたいずれかの方法により形成され、前記方法はマスクを前記型母材の回転対称面に接する位置又は回転対称面から上方に離れた位置に配置した状態で、前記型母材の回転対称面に粒子を照射することにより行うことが好ましい。また、上記各構成において、前記型の回転非対称形状がトーリック面又はシリンドリカル面であることが好ましい。また、上記各構成において、前記回転非対称形状は、光学素子に転写された際に、軸上波面収差の非点収差成分を生じる形状であることが好ましい。

【0027】さらに、型母材を直接エッチングする場合には、前記型の回転非対称表面に保護膜を均一に形成することが好ましい。

【0028】

【発明の実施の形態】

（第１の実施形態）本発明の光学素子の製造方法及びそれに適する型の製造方法の第１の実施形態について、図１から図５及び図１２及び図１３を参照しつつ説明する。本発明の方法により製造されるべき光学素子５０は、例えば非球面レンズであり、図１２に示す。光学素子５０の光学機能面５１は回転非対称非球面であり、垂直な稜線５２及び水平な稜線５３を有する。垂直方向の曲率半径と水平方向の曲率半径とは異なる。それゆえ、稜線５２及び５３はそれぞれ２つの異なった点に焦点を結ぶ。光学素子５０はその軸上において非点収差を有する。光学素子５０は、一対の型の間に配置された光学素材をプレス成型することにより、製造される。少なくとも型の１つは回転非対称非球面を有し、回転非対称非球面は光学素材の表面に転写される。それゆえ、光学素子５０の光学機能面５１が形成される。

【0029】次に、回転非対称非球面を有する型の製造方法について説明する。図１に示すように、中間組み立て体１００は型母材１と、マスク４とマスク治具７を具備する。型母材１は、タングステン（W）及びカーボン（C）を主成分とする超硬合金で出来ている。型表面の傷付きや成形時の光学素材の融着を防ぐために、型母材１の表面１ａ上に保護膜２を形成してもよい。マスク４は、マスク治具７を介して型母材１の表面１ａ又は保護膜２の表面３よりも上方に所定距離だけ離れた位置に配置されている。アルゴン（Ａｒ）イオンビーム６は、型母材１の表面１ａ又は保護膜２の表面３をエッチングするために、マスク４の上方から下方に照射される。型母材１は、型製造工程が完了した時点で、回転非対称非球面を有する型となる。

【0030】型母材１の表面１ａには、従来の回転対称非球面を形成するための方法により、あらかじめ回転対称な非球面が形成されている。型母材１は、製造されるべき光学素子の光軸に対応する軸を中心として回転される。そして、研削砥石と型母材の接する加工点が光学素子５０の所定方向、例えば図１２の稜線５２に沿った非円弧の断面形状を描くように、砥石を送り運動させる。この加工法により加工された型母材１の形状精度は±０．１μｍ程度であった。型母材１の表面１ａに保護膜２を形成する場合、プラチナーイリジウム（Ｐｔ－Ｉｒ）合金等の保護膜をスパッタ法により厚さ３μｍで成膜する。

【0031】図２から明らかなように、斜線部は型母材１のマスク４により遮へいされている部分である。例えば、エッジ部を含めた型母材１の成形面の直径は５ｍｍであり、表面１ａ又は３の直径は４ｍｍである。矩形開口５の大きさは５ｍｍ×２ｍｍであり、各開口５は１ｍｍの間隔をおいて平行に配置されている。

【0032】次に、図１に示す上記中間組み立て体１００を図４に示すエッチング装置に配置する。第１の実施形態では、ＥＣＲ(electron cyclotron resonance)イオンビームエッチング装置を用いている。エッチング装置は、エッチング室９と、中間組み立て体１００が装着されるステージ１０と、エッチング室９の上端部に設けられたイオンビーム加速電極１１と、エッチング室９の上に設けられたイオン銃１３を具備する。

【００３３】中間組み立て体１００がステージ１０に装着されると、エッチング室９の内部が真空となるように空気が除去される。その後、アルゴン（Ａｒ）ガスを、ガス導入バルブ１４を介してイオン銃１３内に導入し、プラズマ１２を発生させる。イオン加速電極１１はプラズマ１２からＡｒイオンを引きだし、イオンビーム６を中間組み立て体１００に照射する。型母材１の表面１ａ又は保護膜２の表面３の原子又は分子は、飛来してきたイオンの衝突により、弾き飛ばされる。それにより、型母材１の表面１ａ又は保護膜２の表面３のエッチング加工が行われる。

【００３４】第１の実施形態において、中間組み立て体１００の最大直径は１５ｍｍであった。エッチング室９内のステージ１０上に７つの中間組み立て体１００を装着した。イオン銃１３からのイオンビーム束の直径は６０ｍｍであった。マスク４は、型母材１の表面１ａ又は保護膜２の表面３から１０ｍｍ離した。エッチング条件は以下の通りである。導入Ａｒガスの圧力０．０９Ｐａ、イオンビーム６の加速電圧８００Ｖ、イオンビーム６の電流密度１．０ｍＡ／ｃｍ^2、イオンビーム６の照射時間３分であった。

【００３５】型１個当たりの加工に要した時間は、中間組み立て体１００の組み立て時間、中間組み立て体１００をエッチング室９内にセッティングする時間及びエッチング室９の内部を真空にするために空気を引く時間を含めて、約９０分（１時間半）であった。もし、イオンビーム束の直径を更に大きくすることができれば、多数の型を効率的に製造することができる。

【００３６】以上のようにして形成された型の断面形状を、図２及び図３に示すＸ軸及びＹ軸方向に測定した。測定結果を図５に示す。図５において、横軸は型中心から測定点までの距離を表し、縦軸は測定点におけるエッチングする前の回転対称な形状とエッチング後の回転非対称な形状とのずれ量を型の中心を０として表したものである。図５から明らかなように、型母材１の表面１ａ又は保護膜２の表面３のＹ軸に沿った領域はマスク４で蔽われ、イオンビーム６により均一にエッチングされるので、Ｙ軸方向の型の断面形状はエッチング前の回転対称な形状から変化していない。一方、Ｘ軸方向に型の中心から離れた領域は中心部分よりも多くイオンビーム６にさらされるので、Ｘ軸方向の型の断面形状は中心から周辺部に向かってゆるやかに傾斜している。その結果、エッチング後の型母材１の表面１ａ又は保護膜２の表面３の表面形状は、例えばトーリック面のような回転非対称となる。Ｘ軸方向の型の全体的な曲率半径は、Ｙ軸方向の型の曲率半径よりも大きくなる。

【００３７】さらに、回転対称な表面を有する別の型を、従来の方法によりあらかじめ用意しておく。図１３に示すように、例えばガラスや樹脂等の光学素材６０を型６１と６２の間に配置する。型６１と６２のいずれか一方は、上記エッチング方法により形成された回転非対称面を有し、他方は従来の方法で形成された回転対称面を有する。型６１及び６２と光学素材６０は、少なくとも光学素材６０の表面が軟化する所定の温度に加熱される。型６１及び６２は、型６１及び６２の表面形状が光学素材６０の表面に転写されるように、所定の圧力でプレスされる。その後、型６１及び６２と光学素材６０は冷却され、回転非対称な光学機能面５１を有する非球面レンズである光学素子５０が得られる。

【００３８】第１の実施形態において、外周部におけるＸ軸方向の型の断面形状の最大ずれ量を０．１５μｍとした。上記エッチング工程を５回繰り返し、合計で３５個の型を製作した。型の形状誤差は、設計ずれ量０．１５μｍに対して±０．０２μｍであった。

【００３９】プレス成型工程を繰り返し、同一型で１０００個のレンズを成形した。光学素材として光学ガラスＳＦ８を用いた。上記型を用いて成型した光学素子５０は、例えばトーリック面等の回転非対称な光学機能面５１を有するので、光学素子５０は非点収差を発生する。光学素子５０の光学性能を測定したところ、各光学素子５０はほぼ同じ方向にほぼ同じ量の非点収差を発生させた。非点収差の平均値は３０ｍλ（ｍλ：用いられる光源の波長の１／１０００）であり、光ディスク装置用光ヘッドの対物レンズとして適度な値であった。その上、光学素子５０全体の波面収差も良好であった。この光学素子５０を用いて光ヘッドを組み立てた。光学素子５０は、回転非対称非球面による軸上非点収差によって光ディスクの半径方向の軸外非点収差が相殺されるように取り付けられている。第１の実施形態の光学素子５０を用いた光ヘッドによる光ディスクの再生特性は、従来の回転対称形状のレンズを用いた従来の光ヘッドを用いた再生特性よりも優れていた。

【００４０】マスク４の開口５の形状、マスク４と型母材１の表面１ａ又は保護膜２の表面３との距離、エッチング条件及びエッチング量を制御することにより、所望の回転非対称形状を型に形成することができる。それにより、所望する非点収差を発生させる光学素子を得ることができる。

【００４１】第１の実施形態では、型母材又はその表面の保護膜をエッチングするためにアルゴンイオンを照射したが、他のイオンやラジカルを用いたドライエッチング法であっても、同様の形状を得ることができる。さらに、保護膜２を形成する場合、エッチング処理の前に型母材１の表面１ａに保護膜２を形成し、保護膜２の表面３をエッチングしたが、保護膜２を形成する前に型母材１の表面１ａを回転非対称にエッチングし、そのあと保護膜２を均一に形成してもよい。さらに、マスクを用いずに、型母材１の表面１ａ又は保護膜２の表面３をイオンビームを操作(scanning)させることによりエッチングを行ってもよい。

【００４２】（第２の実施形態）本発明の光学素子の製造方法及びそれに適する型の製造方法の第２の実施形態について、図６から図８を参照しつつ説明する。第２の実施形態において、製造されるべき光学素子の形状及び型を用いた光学素子の製法工程は第１の実施形態の場合と実質的に同じである。しかしながら、回転非対称非球面を有する型の製造方法が異なる。

【００４３】図6に示すように、開口２３及び２４を除いて型母材２０の全面がレジスト膜２２により蔽われている。開口２３は、型母材２０の表面２１に対向するように形成されている。マークを形成するための開口２４は、表面２１のエッジ部２１ａに対向するように形成されている。レジスト膜２２を有する型母材２０はエッチング溶液２５に浸されている。それゆえ、型母材２０の表面２１は回転非対称形状にエッチングされる。型母材２０は、クロム合金ステンレス工具鋼でできている。

【００４４】型母材２０の表面２１は、従来の方法により、大まかに回転対称非球面形状に形成されている。少なくとも型母材２０の表面２１には無電解ニッケルメッキ膜（図示せず）が施されている。さらに、型母材２０の表面２１上のニッケルメッキ膜は超精密旋盤を用いてダイヤモンド工具により切削される。それゆえ、型母材２０上の表面２１上のニッケルメッキ膜は、例えば図１２に示す稜線５２に沿った光学素子５０の断面形状に正確に一致するように回転対称非球面に仕上げられる。エッチング溶液２５としては、硫酸の５倍希釈液を用いた。

【００４５】例えば、型母材２０の表面２１の半径は２ｍｍであり、平坦なエッジ部２１ａの幅は１ｍｍであった。従って、エッジ部を含む型母材２０の成型面の全半径は３ｍｍであった。開口２３及び２４を除く型母材２０の全表面は、エッチング溶液２５によってエッチングされないように、レジスト膜２２により蔽われている。開口２３は図７に示す軸Ｙに沿って配置されている。開口２３の幅は１ｍｍであり、長さは約４ｍｍであった。開口２４は軸Ｙと直交する軸Ｘ上に設けられている。開口２４の直径は０．６ｍｍであった。

【００４６】エッチング溶液２５は、直径約２００ｍｍのガラス容器に満たされ、４０℃に保温されている。最大直径１６ｍｍのレジスト膜で蔽われた型母材２０を４０個樹脂成のかごに並べ、５分間エッチング溶液２５に浸した。その後、かごをエッチング液２５から引き上げ、純水で洗浄した。その結果、型母材２０の表面２１上のニッケルメッキ膜は回転非対称にエッチングされた。

【００４７】上記方法により形成された型の断面形状を図７に示すＸ軸及びＹ軸方向に測定した。測定結果を図８に示す。図８において、横軸は型中心から測定点までの距離を表し、縦軸は測定点におけるエッチング前の回転対称な形状とエッチング後の回転非対称な形状とのずれ量を型の中心を０として表したものである。図８から明らかなように、型母材２０の表面２１上のニッケルメッキ膜のＹ軸方向の中心部分はレジスト膜２２で蔽われておらず、エッチング液２５によりにより均一にエッチングされるので、Ｙ軸方向の型の断面形状はエッチング前の回転対称な形状から変化していない。一方、Ｘ軸方向の表面２１上のニッケルメッキ膜の周辺部はレジスト膜２２で蔽われており、型の中心部分は周辺部分よりもエッチング液により多くエッチングされるため、Ｘ軸方向の型の断面形状において、周辺部分は中心部分に対して相対的に約０．１μｍ高くなっている。さらに、図８の距離（半径）－２から－３の部分において、開口２４に対向する位置に凹みが形成されている。その結果、型表面の形状は、例えばトーリック面の様な回転非対称となる。Ｘ軸方向の型の曲率半径は、Ｙ軸方向の型の曲率半径よりも相対的に小さくなる。

【００４８】上記方法により形成された４０個の型の形状を測定したところ、Ｘ軸方向の型の断面形状の形状誤差は、平均ずれ量０．１μｍに対して－０．０２μｍから＋０．０３μｍの範囲内であり、ばらつきは小さかった。

【００４９】なお、光学素子の成型時における型表面の傷付きや光学素材の融着を防ぐために、プラチナータンタル（Ｐｔ－Ｔａ）合金の保護膜をスパッタリング法により、型の回転非対称面に、厚さ２μｍの保護膜を形成した。

【００５０】さらに、回転対称非球面を有する他の型を用意しておく。図１３に示す第１の実施形態と同様に、ポリカーボネイト樹脂製の光学素材６０を型６１と６２の間に配置する。型６１と６２のいずれか一方は上記エッチング方法により形成された回転非対称面を有し、他方は従来の方法で形成された回転対称面を有する。光学素材６０及び型６１及び６２を所定の温度に加熱した後、型６１と６２を所定の圧力でプレスした。その後、光学素材６０及び型６１及び６２を冷却した。この様にして、光学素子５０が得られた。

【００５１】このようなプレス成型工程を繰り返すことにより、同一型で１０００個のレンズを成形した。図１３に示すように、上記型を用いたプレス成型により製造した光学素子５０はトーリック面等の回転非対称光学機能面５１を有するので、光学素子５０は非点収差を発生する。光学素子５０の光学性能を測定したところ、各光学素子５０はほぼ同じ方向にほぼ同じ量の非点収差を発生させた。非点収差の平均値は２５ｍλ（ｍλ：用いられる光源の波長の１／１０００）であり、光ディスク装置用光ヘッドの対物レンズとして適度な値であった。その上、光学素子５０全体の波面収差も良好であった。この光学素子５０を用いて光ヘッドを組み立てた。図７及び図８に示すように、回転非対称の方向を示すマークを検出することにより、光学素子の位置決めを行った。第

２の実施形態では、実際に非点収差を測定する必要がないので、光学素子５０が光ヘッドに装着される際に、最適な光学性能を有する方向に光学素子５０を容易に取り付けることができる。第２の実施形態の光学素子５０を用いた光ヘッドによる光ディスクの再生特性は、従来の回転対称形状の型によって成形したレンズを用いた従来の光ヘッドを用いた再生特性よりも優れていた。

【００５２】レジスト膜２２の開口２３の形状、エッチング条件及びエッチング量を制御することにより、所望の回転非対称形状を型に形成することができる。それにより、所望する非点収差を発生させる光学素子を得ることができる。さらに、エッチング工程は図６に示す例に限定されない。表面２１を含む型母材２０の一部分だけをエッチング溶液に浸してもよい。この場合、レジスト膜２２は型母材２０の表面２１近傍のみに設ければよい。エッチング溶液２５の成分は、型母材２０の材料をエッチングできるものであればよい。第２の実施形態では、型母材２０の表面２１上のニッケルメッキ膜をエッチングするために硫酸を用いたが、型母材又はその表面の保護膜をエッチングできるものであれば、他のものを用いてもよい。また、第２の実施形態では型母材２０の表面２１上のニッケルメッキ膜をエッチングしたが、型母材２０の表面２１を直接エッチングしてもよい。

【００５３】（第３の実施形態）本発明の光学素子の製造方法及びそれに適する型の製造方法の第３の実施形態を、図９から図１１を参照しつつ説明する。第３の実施形態において、製造されるべき光学素子及び型を用いた光学素子の製造工程は第１の実施形態と実質的に同じである。しかしながら、回転非対称非球面を有する型の製造方法が第１の実施形態とは異なる。第３の実施形態においては、回転非対称な型の形成方法としてスパッタリング法を用いている。

【００５４】図９に示すように、中間組み立て体２００は型母材３０と、マスク３３とマスク治具３５を具備する。マスク３３は型母材３０の上方にマスク治具３５を介して配置されている。スパッタ粒子３６は、マスク３３の上方から下方に向かって飛来し、型母材３０の表面に膜３１を形成する。型母材３０はアルミナを主成分とするサーメットでできている。

【００５５】スパッタリング工程に先立って、従来の方法により、型母材３０の表面３０ａに回転対称非球面を形成する。型母材３０を成形されるべき回転非対称非球面レンズ等の光学素子の光軸に対応する軸を中心として回転させる。研削砥石は、砥石と型母材の接する加工点が、光学素子５０の所定方向、例えば図１２の陵線５２に沿った非円弧断面形状を描くように送り運動される。

【００５６】図１０に示すように、斜線部はマスク３３により型母材３０を遮蔽している部分である。例えば、型母材３０の表面３０ａの直径は６ｍｍであり、矩形開口３４の大きさは６ｍｍ×４ｍｍであった。マスク３３と型母材３０の表面３０ａとの距離は５ｍｍであった。

【００５７】次に、１４個の中間組み立て体２００をスパッタリング装置の直径約１００ｍｍのホルダ上に配列し、スパッタリング装置の内部の空気を引いて真空にした。その後、アルゴン（Ａｒ）ガスをスパッタリング装置内に導入した。アルゴンガスの圧力を０．１３Ｐａとし、ＲＦパワー１００Ｗで放電を発生させた。Ｐｔ－Ｒｅをターゲットとして、スパッタリングを６０分間行った。その結果、不均一な厚さを有する膜３１が、回転非対称となるように型母材３０の表面３０ａ上に形成された。第３の実施形態では、膜３１の材料はスパッタリング法により形成されたプラチナーレニウム（Ｐｔ－Ｒｅ）合金である。この膜３１は、傷付きや成形時の光学素材融着を防ぐための保護膜としても機能する。型の中心部分における膜３１の厚さは２μｍであった。また、Ｘ軸方向に型の中心から２．５ｍｍ離れた位置における膜３１の厚さは１．８７μｍであった。最初の回転対称な形状からのＸ軸方向における型の断面形状の変位量は０．１３μｍであった。型の形状誤差は平均変位量０．１３μｍに対して±０．０２μｍであった。

【００５８】図１０に示すＸ軸及びＹ軸方向の型の断面形状を測定した。測定結果を図１１に示す。図１１において、横軸は型中心から測定点までの距離を表し、縦軸は測定点における型母材３０の表面３０ａ上に形成されたオリジナルの回転対称な形状と膜３１の表面３２とのずれ量を型の中心を０として表したものである。図１１から明らかなように、Ｙ軸方向における型母材３０の表面３０ａの中心部分はマスク３３により蔽われておらず、膜３１がその上に均一に形成されるため、Ｙ軸方向の型の断面形状は型母材３０の表面３０ａの最初の形状から変化していない。一方、Ｘ軸方向における型母材３０の外周部近傍はマスク３３により蔽われており、型母材３０の表面３０ａの中心部近傍に付着する粒子の量は周辺部に付着する粒子の量よりも多いため、Ｘ軸方向における型の断面形状は中心部から外側に向かって緩やかに傾斜する形状になる。その結果、型母材３０上の膜３１の表面３２に対応する型の表面形状は、例えばトーリック面等の回転非対称となる。Ｘ軸方向の加担曲率半径は、全体としてＹ軸方向の曲率半径よりも大きくなる。

【００５９】さらに、回転対称非球面を有する別の型を用意し、図１３に示す第１の実施形態と同様に、型６１と６２の間に光学ガラスＶＣ７９でできた光学素材６０を配置した。型６１及び６２の一方は上記スパッタリング法により形成された回転非対称非球面を有し、他方は従来の方法により形成された回転対称非球面を有する。光学素材６０及び型６１及び６２を所定の温度に加熱し、型６１及び６２を所定の圧力でプレスした。その後、光学素材６０及び型６１及び６２を冷却した。このようにして、光学素子５０が得られた。

【００６０】この様なプレス成型工程を繰り返し、同じ

型で１０００個の光学素子を製造した。上記型により成型された光学素子５０は、例えばトーリック面等の回転非対称光学機能面５１を有するので、光学素子５０は非点収差を発生する。光学素子５０の光学性能を測定したところ、各光学素子５０はほぼ同じ方向にほぼ同じ量の非点収差を発生した。非点収差の平均値は２５ｍλ（ｍλ：用いられる光源の波長の１／１０００）であり、光ディスク装置用光ヘッドの対物レンズとして適度な値であった。そのうえ、光学素子５０全体の波面収差も良好であった。この光学素子５０を用いて光ヘッドを組み立てた。光学素子５０は、回転非対称非球面によって光磁気ディスクの半径方向の軸外非点収差が相殺されるように取り付けられている。第３の実施形態の光学素子５０を用いた光ヘッドによる光磁気ディスクの再生特性は、従来の回転対称形状のレンズを用いた従来の光ヘッドの再生特性よりも優れていた。

【００６１】マスク３３の開口３４の形状、マスク３３と型母材３０の表面３０ａとの距離、スパッタリング条件及び型母材３０の表面３０ａに付着する粒子の量等を制御することにより、所望の回転非対称形状を型に形成することができる。それにより、所望する非点収差を発生させる光学素子を得ることができる。

【００６２】第３の実施形態では、膜３１を形成する方法としてスパッタリング法を用いたが、ＰＶＤ(physical vapor deposition)法やＣＶＤ(chemical vapor deposition)法を用いてもよい。また、保護膜を兼ねる膜３１を回転非対称に形成したが、中間層を回転非対称に形成し、中間層の上に保護膜を均一に形成してもよい。

【００６３】上記第１、第２及び第３の各実施形態において、図２、図７及び図１０の各平面図に示すように、型母材１、２０及び３０は型全体が回転対称形であるが、型母材の形状は必ずしも回転対称形には限定されない。例えば光学機能面が形成される表面が回転対称であれば、型母材の他の部分、例えば成形面の外周部、型の首あるいはツバ等の光学機能面が形成される部分以外の形状については、矩形断面等の回転非対称形であってもよい。

【００６４】さらに、上記各実施形態において、型又は保護膜の表面１ａ、３、２１及び３０ａの形状はそれぞれＹ軸に対して対称であるが、本発明を軸非対称な光学機能面を形成するために応用することができる。マスク４及び３３、マスク治具７及び３５の構成は上記図示した実施形態には限定されず、エッチング粒子又は成膜粒子を遮蔽し得るものであればよい。

【００６５】

【発明の効果】以上のように、本発明の光学素子の製造方法は、光学素材を一対の型の間に配置する工程と、光学素材及び型を所定の温度に加熱する工程と、光学素材の表面に型の形状を転写するために型を押圧する工程を具備し、型の少なくとも１面は回転非対称である。この方法によれば、型の回転非対称形状が光学素子の表面に転写されるので、同一の光学的性能を有する光学素子を大量生産することが可能になる。

【００６６】また、型の回転非対称形状は、型母材又はその表面に設けられた保護膜の回転対称な表面を不均一にエッチングすることにより、または、型母材の回転対称な表面上に不均一に膜を堆積させることにより形成されるので、特別なそして高価な加工機を用いることなく、型の製造が容易になる。また、表面に回転対称な形状を有する型母材は、従来の切削又は研削方法により容易に形成することができる。さらに、エッチング処理又は成膜処理において、エッチングレート又は成膜レートが安定しているので、その加工量を容易に制御することができる。それゆえ、型母材の最初の回転対称形状を損なうことなく、型の回転非対称形状を正確に形成することができる。

【００６７】また、型の回転非対称形状を、型母材等の回転対称な表面上又は回転対称な表面から上に離れた位置にマスクを配置する工程と、マスクを通して型母材等の回転対称な表面にイオン又はラジカルを照射する工程を有するドライエッチング処理により形成するか、または、エッチングされるべき所定形状の部分を除く少なくとも型母材等の回転対称な表面にレジスト膜を形成する工程と、少なくとも型母材等の回転対称な表面をエッチング液中に浸す工程を有するウエットエッチング処理により形成することにより、従来より行われているエッチング処理技術を応用することができる。その結果、新たに特殊な装置や技術を用いることなく、比較的容易に回転非対称な型を得ることができる。

【００６８】また、上記型母材の回転対称な表面上に不均一に膜を堆積させる方法において、型の回転非対称形状は、型の回転対称な表面上又は回転対称な表面から上に離れた位置にマスクを配置する工程と、型母材の回転対称な表面に粒子を照射する工程を有する、スパッタリング法、ＰＶＤ(physical vapor deposition)法及びＣＶＤ(chemical vapor deposition)法から選ばれたいずれかの方法により形成することができ、従来より行われている成膜技術を応用することができる。特に、従来の方法では製作が困難であったトーリック面又はシリンドリカル面を型の表面に形成することが可能となる。さらに、エッチング処理又は成膜処理により、多数の型を同時に形成することができる。それゆえ、型１個当たりの形成に要する時間を短くし、また型１個当たりのコストを低減させることができる。

【００６９】また、マスクを通して型母材の表面をエッチングする又は型母材の表面に膜を形成する方法において、型母材の光学機能面は、マスクの開口部の形状及び／又は型母材の光学機能面に対する光学機能面の位置を調節することにより、所望の形状に形成することができる。さらに、成膜法は、従来から行われている型の光学

機能面への保護膜や離型膜の形成工程に適用することが可能であり、型の製造工程数を増やすことなく回転非対称な型を形成することができる。

【００７０】さらに、型の回転非対称な形状は、この回転非対称な形状が光学素子に転写された場合に、軸上波面収差に非点収差成分を発生させるように構成されているので、上記方法により製造された少なくとも１つの回転非対称光学機能面を有する非球面レンズ等の光学素子は、軸上の波面収差に非点収差成分を発生させることができる。それゆえ、ほぼ同じ方向にほぼ同じ量の非点収差を発生させる光学素子を量産することができる。

【００７１】また、光学素子の回転非対称光学機能面により発生される非点収差の方向を検出し、光学素子の（取り付け）方向をマーキングすることにより、そのマークを光学装置の所定の位置に位置決めすることにより光学素子を容易に装着することができる。それゆえ、非点収差をモニターしながら光軸に対する光学素子の方向を調節することを省略することができる。さらに、型のエッジ部分にマークに対応する凹凸形状を形成すれば、光学素子の製造と同時に光学素子のエッジ部にマークを形成することができる。それゆえ、回転非対称な光学機能面により発生される非点収差の方向の検出を省略することができる。

【図面の簡単な説明】

【図１】本発明の光学素子の製造方法及びそれに適する型の製造方法の第１の実施形態において用いられる型を形成する方法及び中間組み立て体を示す断面図

【図２】第１の実施形態における型母材とマスクの形状及び相対位置を示す図１に示した中間組み立て体の平面図

【図３】第１の実施形態において形成された型の形状を示す斜視図

【図４】型を形成するために第１の実施形態で用いられるエッチング装置を示す側部断面図

【図５】第１の実施形態における図２及び図３の軸Ｘ及びＹ方向のエッチング後の型の断面形状に対応するデータを示すグラフ

【図６】本発明の光学素子の製造方法及びそれに適する型の製造方法の第２の実施形態において用いられる型を形成する方法を示す側部断面図

【図７】第２の実施形態における型母材とマスクの形状及び相対位置を示す型母材の中間段階の平面図

【図８】第２の実施形態における図７の軸Ｘ及びＹ方向のエッチング後の型の断面形状に対応するデータを示すグラフ

【図９】本発明の光学素子の製造方法及びそれに適する型の製造方法の第３の実施形態において用いられる型を形成する方法及び中間組み立て体を示す側部断面図

【図１０】第３の実施形態における型母材とマスクの形状及び相対位置を示す図９に示した中間組み立て体の平面図

【図１１】第３の実施形態における図１０の軸Ｘ及びＹ方向の成膜後の型の断面形状に対応するデータを示すグラフ

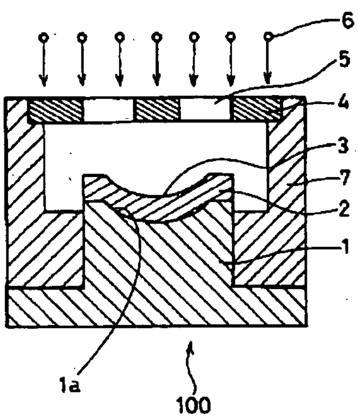
【図１２】本発明の方法により製造される光学素子を示す斜視図

【図１３】本発明の光学素子の製造方法のプレスモールディング工程を示す側部断面図

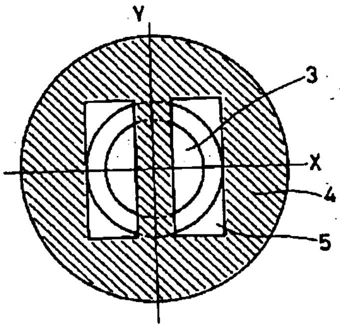
【符号の説明】

１　：型母材
１ａ：型母材表面
２　：保護膜
３　：保護膜表面
４　：マスク
５　：矩形開口
６　：イオンビーム
７　：マスク治具
９　：エッチング室
１０　：ステージ
１１　：イオンビーム加速電極
１２　：プラズマ
１３　：イオン銃
１４　：導入バルブ
２０　：型母材
２１　：型母材表面
２２　：レジスト膜
２３　：開口
２４　：開口
２５　：エッチング液
３０　：型母材
３０ａ：型母材表面
３１　：膜
３２　：膜表面
３３　：マスク
３４　：矩形開口
３５　：マスク治具
３６　：スパッタ粒子
５０　：光学素子
５１　：光学機能面
５２　：稜線
５３　：稜線
６０　：光学素材
６１　：型
６２　：型
１００　：中間組み立て体
２００　：中間組み立て体

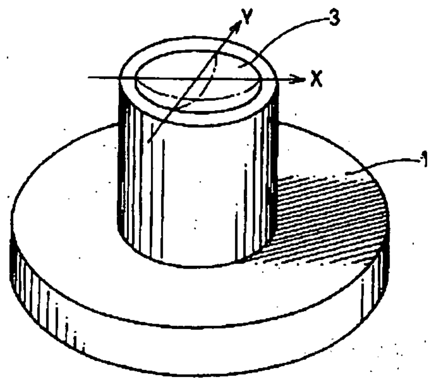
【図1】



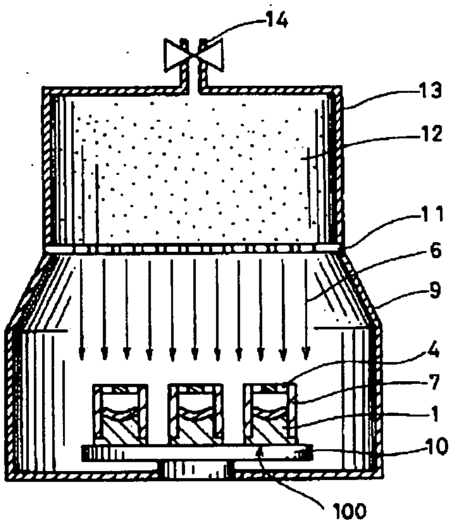
【図2】



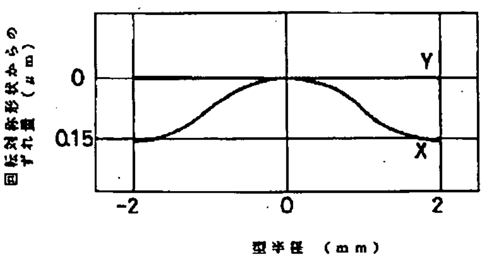
【図3】



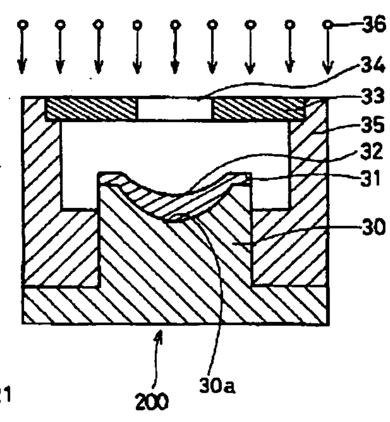
【図4】



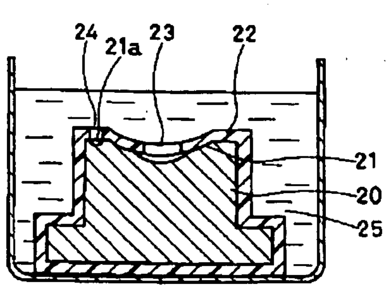
【図5】



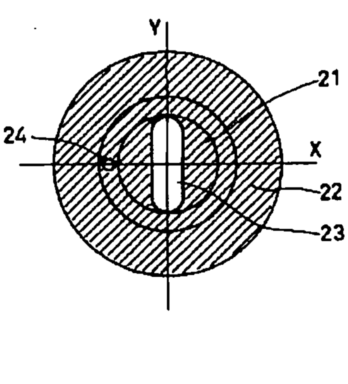
【図9】



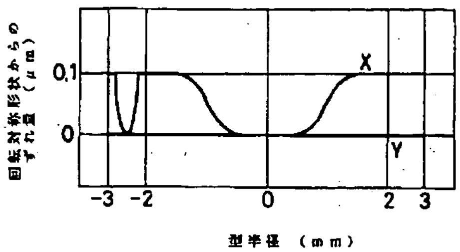
【図6】



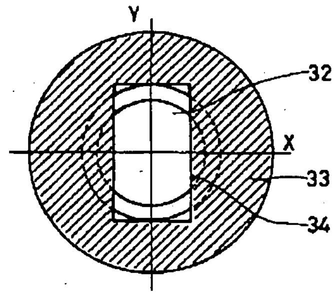
【図7】



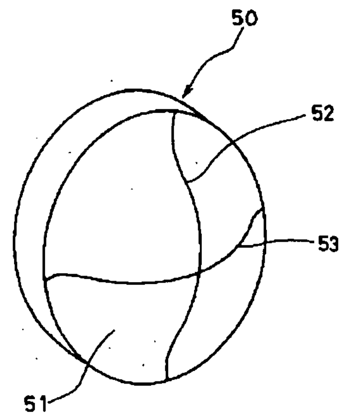
【図８】



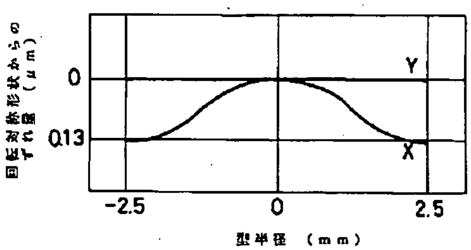
【図１０】



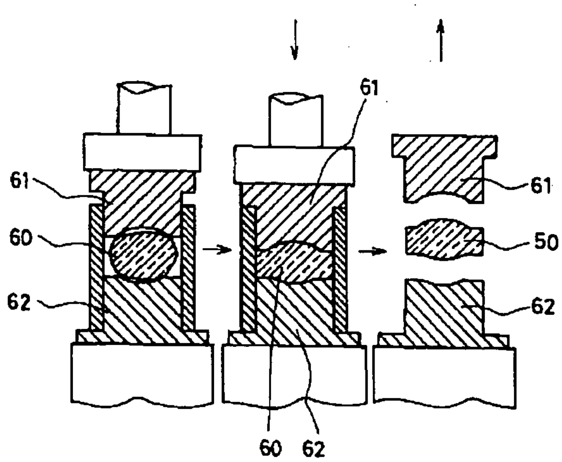
【図１２】



【図１１】



【図１３】



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